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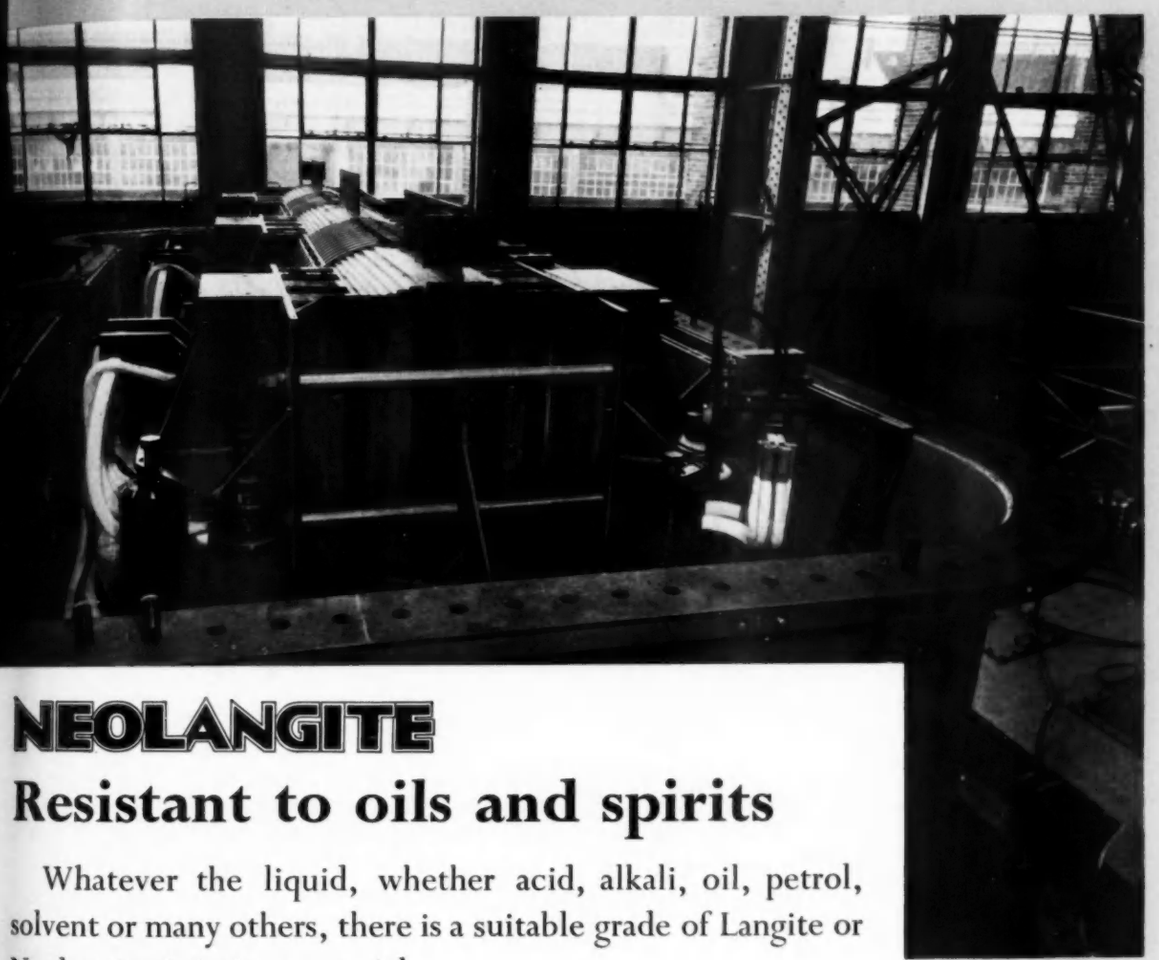

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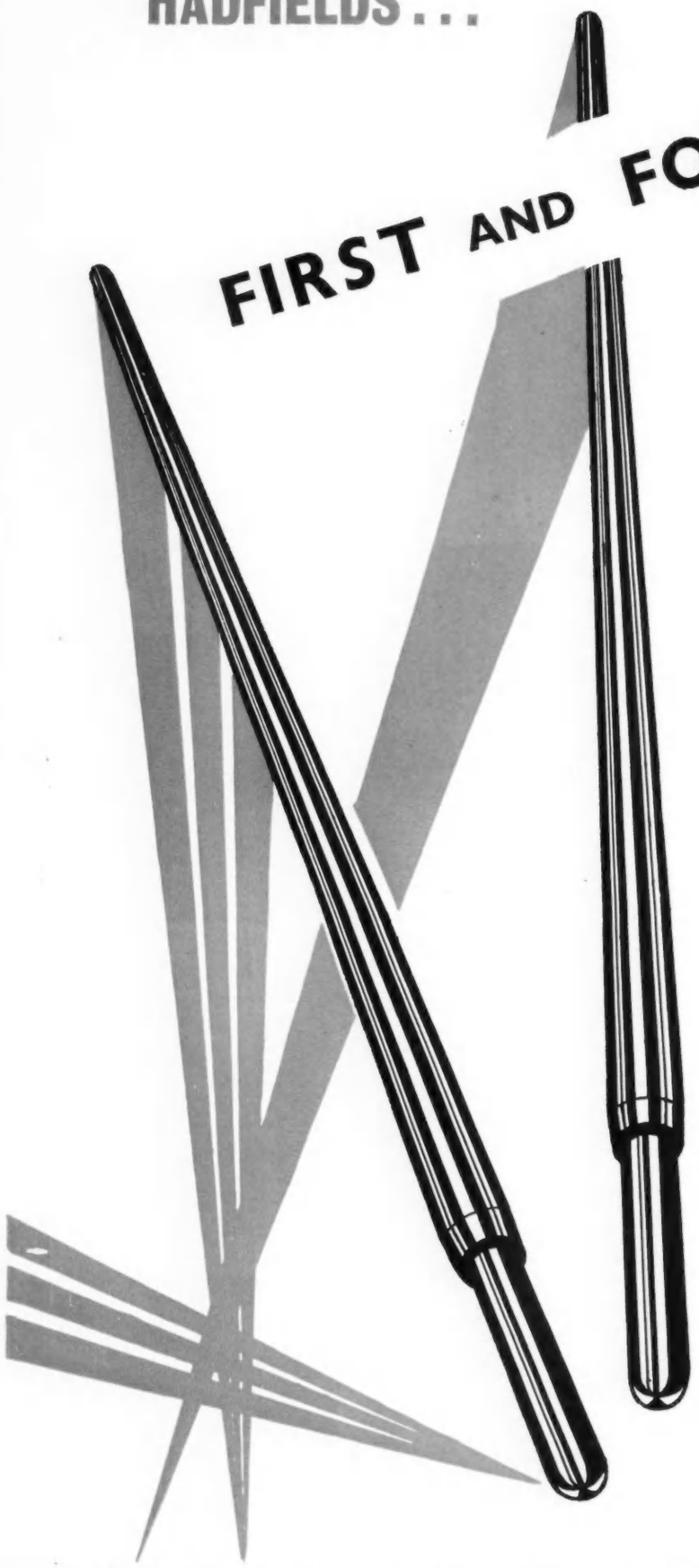

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No. 5520 **NOVEMBER 10, 1961** VOL. 212

EDITORIAL CONTENTS

Leading Articles

Imported Methane . . . 767
The Blind in Industry . . . 767
Putting up With Pylons . . . 768
High Definition Television on V.H.F. . . . 768
More Conference Organisation . . . 769
National Coal Board Finances . . . 769
Retirement of Major R. F. Maitland . . . 769

Articles

100 Years Ago . . . 769
G. V. E. Thompson American Spaceflight Meetings. No. II . . . 770
Carbon Brush Conference . . . 774
E. C. Poultney Notable Locomotives of 1911 . . . 777
I.C.E. Presidential Address . . . 787
Production by Moulding . . . 788
Foundation Design and Construction . . . 790
European Satellite Launcher . . . 790
350MW Steam Turbo-Generators for Australia . . . 790
Care of Wire Ropes . . . 791
Importation of Methane for Town Gas Supply . . . 791
Electrolytic Machining . . . 791
Ceramic-Cased Tunnel Diodes . . . 791
Marine Alarm Generator . . . 791
Single-Tank 132kV Three-Phase Oil Circuit Breaker . . . 792
Data Processing System Developments . . . 792
1961 Amendments to Wiring Regulations . . . 792
Gas Blowers for Dungeness . . . 792
BEAMA Golden Jubilee Dinner . . . 793
Recording Transistor Life Test Data . . . 793
Polished Stainless Steel Sheet Protection . . . 794
Heavy-Duty Solid-Frame D.C. Motors . . . 794
Two Engineering Exhibitions . . . 794
Ceramic Triode for R.F. Heating . . . 794
Gas-Fired Air Heater . . . 795
High-Power Short-Wave Transmitters . . . 795
Electromechanical Integrator . . . 795
Cleaning Solvent . . . 795

Continental Affairs

Jauntal Bridge . . . 798
Climatic Testing Installation . . . 799
Ore Handling Bridge . . . 800
Société Louis Breguet . . . 800
Milan Underground . . . 800

American Scene

Free Radicals Research at the National Bureau of Standards . . . 801
Investigation of Nuclear Reactor Accident in Idaho . . . 803
Gas Centrifuge Research Programme . . . 804
Award of 1962 John Fritz Medal . . . 804

LETTERS

Pollution of the Tidal Thames . . . 785
Activity in Operational Research . . . 785
A Discrepancy of Indication . . . 785
Variety of Paper Sizes in the U.K. . . . 785

BOOKS JUST PUBLISHED . . . 786

NEWS AND NOTES

Industrial News . . . 796
Personal and Business . . . 797
British Patent Specifications . . . 805
Forthcoming Engagements . . . 806

INDEX TO ADVERTISERS : PAGE 119 **CLASSIFIED ADVERTISEMENTS : PAGE 113**

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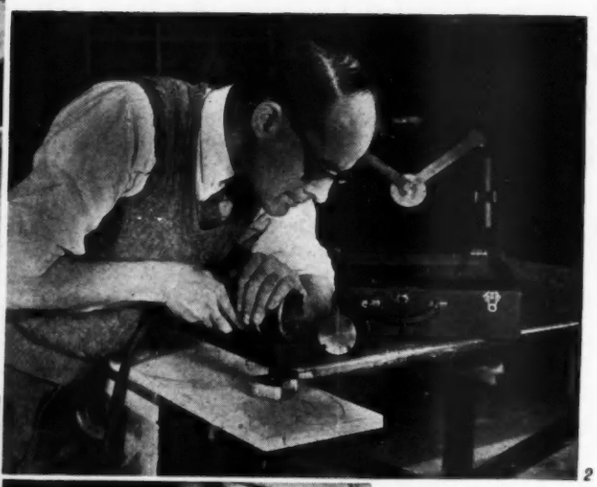

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THE ENGINEER

No. 5520 NOVEMBER 10, 1961 Vol. 212

IMPORTED METHANE

In a statement following the announcement by the Minister of Power that approval had been given to a scheme for the importation of methane gas from the Sahara, the chairman of the Gas Council, Sir Henry Jones, emphasised that it was necessary to seek further means of reducing production costs for the future well-being of the gas industry. The new scheme, some details of which are printed elsewhere in this issue, when it is fully operative, in about four years' time, will provide about ten per cent of the country's gas requirements. It involves an investment of £18,000,000 by the gas industry, whilst associated interests will invest over £14,000,000 in plant and £7,000,000 on two special ships for carrying liquid methane to this country. One of these ships will be built by Vickers-Armstrongs Ltd. and the other by Harland and Wolff Ltd. The investment of £18,000,000 by the gas industry seems a very reasonable sum for a project which promises to reduce gas production costs to 8½d. a therm—as compared with 1s. to 1s. 3d. by conventional carbonisation methods when on a favourable load factor. Under the scheme there will be saved initially 800,000 tons of coal and 400,000 tons of oil products a year.

In announcing his approval of this scheme the Minister of Power pointed out that it was one of several developments which the gas industry was contemplating and that in particular the Gas Council was in discussion with the National Coal Board on the economics of gasifying coal on a large scale by the Lurgi process. He was satisfied that his decision on the methane proposals would in no way prejudge the building of large Lurgi plant if such a plant promised to be competitive, and it would not prevent the industry from expanding its use of petroleum feedstocks. The chairman of the National Coal Board, Lord Robens, has expressed very natural concern that the decision to import methane was made before it was known whether gas could be produced equally cheaply from coal by the Lurgi process. It is believed by the N.C.B. that gas made in a large-scale Lurgi plant can be delivered at a price of between 8¼d. and 8½d. a therm. If this is in fact the case we see little need for the fears of the coalminers and of the N.C.B. that there will be a reducing demand for coal by the gas industry. The methane project should be regarded as a step in development by an associated industry which has, of necessity, to reduce production costs to promote efficiency and expansion, and one which cannot ignore new technologies or cheaper sources of supply. Indeed if the reduction in production costs brought about by the use of Lurgi plants which produce lean gas, by the importation of rich methane gas, and by the development of a gas grid makes gas more competitive as a source of heat with other fuels, especially imported oil (as it should) the ultimate consequence is likely to be an increase in the demand of the gas industry for coal. Surely the project should be a spur to the coal industry to retain a traditional customer. Should large scale Lurgi plant prove to produce gas at a price competitive with that of imported methane, as it contended, coal has little to fear for the future.

THE BLIND IN INDUSTRY

We are always happy to have the opportunity to write about the work of the Royal National Institute for the Blind. Last week the employment department of that Institute made its five thousandth placing of a blind person in industry. To those who know how very competent blind people prove to be in industry it is surprising to realise that before the last war it was generally thought that the blind could be employed only in special sheltered factories doing work such as basket-making. The war provided the opportunity to prove otherwise. The Institute, in co-operation with the Ministry of Labour, set up a "Placement Service" in 1941. The late Ernest Bevin was a keen supporter of the project; and soon local authorities were brought into co-operation too. There were set up more rehabilitation centres where blinded people could regain confidence and learn to do without sight and the "Placement Service" already mentioned was started, manned largely by blind or partially blind people, to investigate possibilities in industry and commerce. For, of course, though there have proved to be plenty of jobs in industry and commerce which the blind *can* do there are many more for which sight is essential; and only the blind can fully understand the capacity of the blind and what is beyond their capacity.

In conversation with others at a reception held to celebrate the five thousandth placement we learnt one or two things that were new to us and which may be new to readers. Firms often prove dubious when the project is put to them that they might employ a blind person. Once, however, some blind person enters some suitable employment with such a firm the initial reluctance quickly vanishes. For experience shows that blind people, even on such a job as capstan lathe operation, can fully hold their own against their sighted fellows, need no more supervision, and contrary to expectation tend to be less accident prone than sighted people. For some jobs, special equipment is needed, for example Braille micrometers; but no extra charge falls on the firm since the equipment is loaned to it, free of charge. Blind people in industry are paid the full rate for the job and are well worth it.

Nowadays there is less difficulty than there used to be in convincing managements that some jobs can be satisfactorily done by a blind person. But there is often initial objection from the men on the shop floor (or an office), unaware of the ability of blind people to look after themselves. No doubt they fear that they will be constantly called upon to neglect their own work in order to assist the new employee or to guard him from danger. Once those fears are proved groundless, so we

are informed, the blinded person usually becomes popular and nearly always proves a good influence in the shop, if only because of his concentration on the job in hand and contentment with it. Britain has a fine record. Statistics show that it has a higher proportion of its blind population gainfully employed than any other country, some 15 per cent. That figure may not sound high; but it needs to be remembered that a large proportion of those who become blind are old or elderly. It is now broadly true that no able-bodied person who has the misfortune to go blind need fear that he will be dependent upon others for the rest of his life. If he, or she, wants to earn an independent living a suitable job is available somewhere.

PUTTING UP WITH PYLONS

An interesting comparison between electricity generation and transmission problems in Great Britain and France was made by Monsieur P. M. J. Ailleret of Electricité de France when he gave a special lecture at the I.E.E. in London on October 26. As M. Ailleret showed, it was an apt comparison for, despite certain important differences between the two electricity systems, there is enough similarity in the general pattern of development to make the exercise both valid and instructive. For example, the rate of growth in demand in the two countries is strikingly similar, leading to doubling every ten years. However the actual consumption per head of population is considerably smaller in France and this fact, coupled with the much lower population density over the country as a whole, means that the density of transmission lines per square mile is much smaller than in England. That, surely, is one reason why, as M. Ailleret affirmed, Electricité de France has comparatively little trouble in the routeing of overhead lines. There are so few of them that their obtrusiveness has not become a major public issue. Indeed wayleaves appear to be relatively easy to obtain, for the French are able to have maximum security and convenience of maintenance by duplicating major lines along parallel routes, almost at will, whereas the British have been forced for many years to concentrate double-circuit lines on common towers.

Electricité de France has perhaps profited by the experience of the British electricity authorities which have, for some decades, faced increasing difficulties in obtaining wayleaves. The French have, of course, taken special care, in planning their latest e.h.v. lines, to develop a design of pylon which is both functional and acceptable to the public. We would not care to pass an opinion on the relative merits of the British and French designs, for this is essentially a matter of personal preference. The important point is that the French supply authority has produced a design which the public is prepared to tolerate. Apparently it has succeeded in implanting an acceptable image in the public mind. We wonder whether there was ever a time when a similar image might have been created in Britain. Or is there a streak of cussedness in the British temperament that expressed itself from the outset in a fixed determination to condemn the towers out of hand? There is some evidence to suggest that the French public adopts a more practical attitude. For we recall seeing some years a large outdoor substation, a few miles south of Paris, where overhead lines from the hydro-electric stations converged for transmission northwards. There is little doubt that if such a substation — a "wirescape" covering several acres of "unspoilt" countryside — had been projected in Britain it would have aroused a storm of public protest. Yet in France it was accepted, apparently without demur. We wonder whether popular objections there will grow as the density of transmission lines increases? Or are the French people being conditioned to accept overhead transmission lines as an industrial concomitant of the rural scene?

HIGH-DEFINITION TELEVISION ON V.H.F.

A booklet published by the Independent Television Authority this week sets out proposals for a programme under which the television line standard in this country would be changed to 625 lines, while retaining channels in the v.h.f. band. The booklet stresses the point that previous plans have involved the withdrawal of v.h.f. television broadcasting and the concentration of these services in the u.h.f. band, where three or four programmes might be established. It would then be possible to consider the re-channelling of the v.h.f. bands for two 625-line transmissions, making six programmes a possibility. However, this would bring the risk that once television broadcasting had moved out of the v.h.f. band, other claimants for these frequencies might arise and an eventual return to them might be impossible. Four advantages of v.h.f. for television are enumerated which make the retention of these frequencies desirable for the two 625-line programmes they could accommodate. They are: greater immunity, compared with u.h.f., from the adverse effects of topography on wave propagation; more extensive and reliable coverage; economy of transmission costs; and help to exports, because "no country, with the choice before it, would ever use u.h.f. until it had fully exploited v.h.f.". The theme of aid to exports occurs again in the booklet's advocacy of 625 as against 405 lines, and the point is made in this connection that while the improvement given by a 625-line picture is to some extent obscured on small screens, it will be fully evident on the possible 27-inch and 30-inch screens of the near future.

The suggested plan for a changeover of line standards provides for an "appointed day" on which all transmissions would become 625-line; it would occur after seven or eight years. In the meantime, at all existing v.h.f. stations, both B.B.C. and I.T.A., "shadow" plant consisting of transmitters and aerials arranged for 625-line operation on their appropriate new v.h.f. channels should be installed. Dual-standard receivers capable of 625-line reception on v.h.f. and u.h.f., and of the existing 405-line services on v.h.f., should be placed on sale from the start. As early as possible the planning and building of a national network of u.h.f. stations should begin, and arrangements be made for the introduction, area by area, of two new programmes on 625 lines. Receivers for the transition period might be equipped with two additional positions on their v.h.f. turret tuners, not initially fitted with coils. As soon as the new v.h.f. channels became known, these coils could be fitted during manufacture of the receivers. Earlier sets could be progressively equipped with new v.h.f. coils by dealers, assisted by trade test transmissions from the "shadow" transmitters. The I.T.A. points out that the problem of colour is not one of transmission, but of reception, particularly as it affects the cost of receivers. It suggests that colour should not be introduced at all in the 405-line transmissions, but that on the "appointed day" for 625 lines, colour transmissions should begin both on the v.h.f. and u.h.f. service. It is not concealed that any plan for transition will be "painful for the broadcasters, the manufacturers

and the public alike," and an appendix on the re-channelling of the v.h.f. bands for 625-line programmes reveals the complexity of the international agreements that will be necessary to avoid interference. It seems unfortunate that the arguments of this booklet were not acted upon in time for Britain to have sought assignments in a re-channelled v.h.f. spectrum at the Stockholm Broadcasting Conference earlier this year.

MORE CONFERENCE ORGANISATION

It never rains but it pours! Some weeks ago we commented in these columns on the setting up of a new company, Conference Hotels Ltd., whose object it would be to "take over" from those who are called upon to organise conferences of one kind or another. At a Press conference in London a few days ago we learnt about another such body, Conference Organisers Ltd., which has very much the same object. It now seems to us possible that more such bodies may be set up in the not distant future, as the services they can offer in that field are comparable with those offered by travel agents in theirs. Much that we wrote some weeks ago is as applicable to Conference Organisers Ltd. as to Conference Hotels Ltd. But there do seem to be minor differences of approach. The latter body, for example, has deliberately linked up with a number of South Coast hotels having halls suitable for conferences. The former appears to have no such linkages but to be willing to organise a conference anywhere at any time. We have the impression that it may be offering certain special services to those who want conferences organised for them, services which it would no doubt fall to the hotels on the South Coast to provide for the other organisation.

Commercially, of course, such firms as these are set up to make money for themselves. But no engineer is going to say there is any harm in that! Providing not too many come into existence, so that a form of cut-throat competition might develop, their advent is surely to be welcomed. At present many conferences are organised by people who have never done such a thing before, are never likely to do such a thing again and to whom much must be forgiven as they do the work for "love". The resultant meetings are only too often held in hotels or halls whose managers or owners are interested only in letting the accommodation and who see no reason why they should provide more than the minimum of equipment or go out of their normal routine to make those who attend more comfortable. It will obviously be to the advantage of any company whose object it is to make money by organising conferences to organise them well; and to see to it that those who attend are accommodated in suitable halls, have somewhere comfortable to stay the night, if necessary, and are properly and attractively fed. Tactfully they may even prove able to offer advice to chairmen and secretaries about the actual running of a meeting!

NATIONAL COAL BOARD FINANCES

There would appear to be but little chance of the long standing unhappy financial conditions of the National Coal Board being alleviated in the near future judging from the remarks of Mr. Wood, the Minister of Power in a recent House of Commons debate, when he was moving a resolution about the report of the N.C.B. for 1960. After pointing out that the revenue deficit at the end of 1960 was £21,000,000 and the accumulated deficit was then £78,000,000 he spoke of the fundamental problem of getting the board's finances on a permanently sound basis and the deficit of financing. It was already certain that there would be a further revenue deficit this year, for although a small surplus had been made in the first half, the second half of the year was a difficult period. This further deficit would bring the board's account beyond the total of its internal resources and of the £20,000,000 borrowing limit.

Mr. Wood pointed out that hard and painful decisions faced the N.C.B. in its efforts to get "out of the red". In connection with the discussions with the Government on the financial objectives for an experimental five-year period the board put in hand an intensive examination of the industry and its prospects. It will be some time, however, before proposals can be made for getting the finances of the industry on a sound basis. What form these proposals will take it is not easy to conjecture, but they will inevitably need to be sweeping and to be carried out with ruthless determination if the industry is ever to get into a sound financial state.

RETIREMENT OF MAJOR R. F. MAITLAND

Major R. F. Maitland has retired after thirty-one years as Secretary of the Institution of Structural Engineers. On Thursday, November 2, at a dinner at the Dorchester Hotel, London, members and officers of the Institution gathered to pay tribute to him and to make a number of presentations, including a gift from the officers of the Institution's ten branches and finally a cheque and a testimonial.

The President, on behalf of the Institution, received from members of the Council a portrait of Major Maitland painted by Mr. Reginald Lewis, R.P. N.E.A.C. The high regard and affection in which Major Maitland is held by members of the Institution of Structural Engineers in all parts of the world was immediately apparent at this function.

The Engineer—100 Years Ago (NOVEMBER 8, 1861)

Engineering Progress

Any time is appropriate for reviewing progress. We did so a hundred years ago, and reached some conclusions which, in their essentials, might well be repeated today. Steam power, naturally, was all-important in 1861, and it was our concern then that while we heard on all sides that the steam engine had been greatly improved, the proofs of the assertion were hard to find. We felt, in fact, and adduced evidence to show, that in steam engineering the main developments had been in re-inventing what had been recorded in the Patent Office twenty, thirty and even fifty years previously. In civil engineering the "... advance beyond the ancients ..." had not been great, and in ship design some of the improvements then coming in had been suggested many years earlier. Ordnance appeared to have been "... travelling in a circle."

It was, in fact only possible to single out two really new discoveries of the period—the "atmospheric process of making iron and steel" and the electric telegraph, and of these the latter was "... more than twenty years old." This was all, perhaps, rather a sour view of the times, but if it only led to a careful appraisal in a few fields, it did no harm. We ended with a comment which is as true today as it was when it was written. "Inventions are, after all, valuable only as they really benefit mankind, and from what we believe to be the constant improvement of society, we may rest assured that we have a great work yet before us in the better development merely of inventions already known and practised."

American Spaceflight Meetings

By G. V. E. THOMPSON, B.Sc. (Eng.), F.B.I.S.

No. II—(*Continued from page 745, November 3, 1961*)

Two memorable meetings on spaceflight took place in America recently. The Twelfth International Astronautical Congress, which was held in Washington, D.C., on October 1 to 7, was organised by the American Rocket Society in association with the Aerospace Medical Association and the American Astronautical Society. It was eclipsed the following week by the American Rocket Society's Space Flight Report to the Nation, a mammoth meeting in New York, accompanied by an unparalleled exhibition at which were displayed present and prototype space capsules, spacecraft, satellites, boosters, missiles and components. The exhibition was later opened to the public ; there were over 5000 professional registrations for the meeting itself. Only the more important engineering aspects are dealt with below.

TWO plenary sessions of delegates of the member societies of the International Astronautical Federation were held. Professor L. I. Sedov (Russia) having served for two successive years as President was ineligible for re-election, but the new office of Past-President was created for him. Professor J. Peres (France) was elected President of the Federation for 1961–62 and the following were elected Vice-presidents : Professor N. Boneff (Bulgaria), Dr. William H. Pickering (U.S.A.), Dr. L. R. Shepherd (U.K.), and Ing. H. B. de Tabanera (Argentine). The U.S.S.R. voluntarily relinquished its right to a vice-presidency, in view of Professor Sedov's seat on the bureau as past-president.

New societies admitted to voting membership were the Cyprus Astronautical Society, and the Sociedad Mexicana de Estudios Interplanetarios. The revised Constitution of the Federation was adopted, and it was agreed to establish a permanent headquarters in Paris, in offices to be provided by the French government.

As previously agreed, next year's Congress will be held in Sofia, Bulgaria, probably in mid-October. Offers to act as hosts for the 1963 Congress were received from the Argentine, West German, Mexican and Polish societies. Professor Sedov strongly advocated acceptance of the Mexican offer, but the British delegation supported the invitation of the Argentine society (a founder-member of the I.A.F.) which had been repeated for several years. As a result, Germany and Poland withdrew their offers, in favour of the Argentine, and it was agreed that the 1963 Congress be held in Buenos Aires. The Yugoslav society made a strong plea for the 1964 Congress to be held in Belgrade, as that country will be launching its first rocket in that year.

SPACE FLIGHT REPORT TO THE NATION

For the convenience of overseas delegates attending this year's International Astronautical Congress in Washington, D.C., it had been arranged that it should immediately precede the American Rocket Society's Annual Meeting, which was held in New York, October 9 to 15. This was the biggest meeting ever organised by the Society (it completely dwarfed the I.A.F. Congress), and included their first exhibition to which the public were admitted (from 5 to 10 p.m. each evening, and during the week-end). In hiring the New York Coliseum for a week, the A.R.S. was staking a considerable sum of money on industrial, professional and public interest in astronautics, but it proved to be an investment rather than a gamble : 175 organisations had displays in the exposition, over 230 papers were read at the meeting, and there were over 5000 professional registrations and a good public attendance.

The significance of the meeting was summed up in a message from President Kennedy :

" The searching examination of United States progress in astronautics provided by the American Rocket Society *Space Flight Report to the Nation* could not be more appropriate nor more timely. Until now, the opportunity for both the professional engineer and scientist and the public to see and hear the whole story has been lacking. It is therefore heartening to see that A.R.S. has taken the lead, in co-operation with government and military agencies, educational and scientific institutions, and industrial companies, in making available, both to the professional and to the public, full information about the present U.S. space programme and, even more important, about this country's future plans for space exploration."

The exhibition was staged on three floors of the Coliseum, and the lecture sessions on a fourth, up to seven sessions being run in parallel. The sessions covered robot exploration, logistics and operational problems of very large boosters, structures and materials, power sources, nuclear rocket mission applications, astrodynamics, instrumentation for manned space flights, missile and space vehicle flight testing, electrostatic thrust generation, propulsion nuclear reactor operation and facilities, evolution of American liquid propellant rocket engines, education, electric propulsion, human factors and bio-astronautics, missiles and space vehicles, electro-thermal and electro-magnetic thrust generation, nuclear instrumentation, hypersonic heat transfer and vaporisation, ablation, special satellites, communication satellite current and future programmes, space law and sociology, technical information (the paper curtain), environment of space, guidance and control, new liquid rocket techniques, N.A.S.A. programme reports, space propulsion components, propellent technology, and magneto fluid mechanics.

Robot Exploration.—Although a recent official analysis of the probable progress of the manned and unmanned lunar exploration programmes showed that the former was likely to succeed first, both are to continue. The first session on the programme concerned robot exploration, and two of the four papers dealt with methods of locomotion, since there is little point in sending a robot machine 250,000 miles to the Moon to analyse the surface if it can only gather specimens within a radius of (say) 5 to 10 yards.

M. G. Bekker (General Motors Corporation) considered that the planning of basic vehicle configurations for the other planets and the Moon could be done by following the trends and methods of land locomotion mechanics that have developed the morphology of off-the-road vehicles on the earth, but the solutions sought for must be general at present as terrain conditions are as yet mostly conjectural. J. D. McKenney (Space-General Corporation) presented an interesting comparison of the advantages and disadvantages of wheels and legs for lunar locomotion, coming down in favour of the latter. His suggested arrangement for a walking device of three pairs of legs arranged in the form of a triangle—one pair in front, two at the rear. The system moves by advancing one set of three legs back in a step while the other three are moving forward in preparation for the next step. Turning is accomplished by steering the forward set of legs. The legs can be folded up during transit to the Moon. A 25 lb kinematic model is now being tested on rough terrain.

S. H. Gross (Airborne Instruments Laboratory) dealt with the problems of controlling a lunar robot vehicle from earth. The problems include the difficulty of judging height, size and distance of unfamiliar objects in T.V. pictures, and the effects of the transmission and data processing delays. Techniques are being developed for the terrestrial screen to show things as they will be when the command reaches the lunar vehicle rather than as they were when the signal was sent from it. A model demonstrating these points was shown on the company's stand in the exposition. M. Eimer and K. W. Linnes (Jet Propulsion Laboratory) discussed remote sampling devices for determining the properties of lunar materials.

Large Boosters.—B. M. Teague and J. R. Youngquist of the Martin Company outlined the procedure in the production, transport and launch of the " Titan " I.C.B.M.'s, then went on to discuss the facilities and logistics that would be needed for a " Nova " class vehicle weighing 9·6 million pounds with a first-stage thrust of 12,000,000 lb and diameter of 50ft. In some respects, production of this would be easier and it is suggested that the production line could manufacture four vehicles per month. The authors recommended launching from a floating platform, the large boosters being brought to the site by barge.

In his paper " Will there be 100,000,000 lb Space Vehicles ? ", C. J. J. Hamlin, Jnr., also favoured a sea launch, but with the vehicle floating upright in the water (under the name " Project Hydra," model tests of this method have been carried out at the U.S. Naval Missile Centre, Point Mugu, California). He answered the question in his title affirmatively, though he thought that these vehicles would probably be limited to using low-impulse solid propellent or LOX/RP1 boosters.

W. J. Hix and E. W. Bolster (Aerojet-General Corporation) dealt with logistic and launch requirements for large solid boosters. They considered that segments up to 288in in diameter and 1,000,000 lb gross weight could be handled, transported and assembled ; segments of 160in diameter weighing up to 250,000 lb could be transported by rail or road for limited distances. Special equipment for handling and assembly was described.

E. G. Johnsen (N.A.S.A.) discussed the test facilities required for the N.A.S.A./A.E.C. nuclear rocket programme, including the Nevada Test Site for the " Nerva " engine. This will have the first down-firing nuclear rocket engine test stand to be built and it will be capable of providing a low atmospheric pressure around the engine so that actual flight conditions can be simulated.

It is envisaged that nuclear spacecraft weighing 900,000 lb to 1,000,000 lb will be assembled in orbit for flight to other planets. The vessels will have three stages propelled by engines having nuclear-thermal powers in the range 1000MW to 8000MW.

J. S. Hamilton, also of N.A.S.A., explored possible techniques for the recovery of large boosters, this being desirable not only for economy but also because of the information gained in inspecting failures. Some tests have been carried out with the H-1 engine (cost 250,000 dollars each) including immersion in salt water and dropping from a height into the sea. The cost of a test, including preservation, cleaning and preparation for static firing is only 8000 dollars. Eight of these engines are used in the first stage of the " Saturn " rocket, and schemes for recovering this booster which are being considered include the use of paraglider (resembling a paper dart in appearance), autogyro, parachute-balloon, and parachute plus retro-rockets.

Structures and Materials.—Over 10 per cent of the papers accepted were concerned with materials and structures, and so these were not presented individually, but divided into groups each summarised by a rapporteur. This proportion is an indication of the importance of materials in astronautics as in other branches of engineering ; to quote the opening words of " New Materials and Processes for Space Flight," by E. D. Sayre (General Electric Company) : " Space flight has run into the materials barrier. There is no question that every one of our advanced systems faces problems due to a lack of adequate materials to meet the design requirements."

There is no reason why some of these materials should not be developed here in Britain, but in general materials firms and research associations have shown little interest in the needs and requirements of astronautics.

In his paper Mr. Sayre reviewed some processes developed by General Electric : roll-forming of solid-propellent rocket cases from a forged steel ring blank, production of pyrolytic graphite or boron nitride for leading edges and rocket nozzles, shear-forming of tungsten nozzles, arc-plasma deposition of refractory metals, and the use of niobium alloys and coatings for re-entry vehicles.

L. W. Mayer (Alcoa) presented the advantages of aluminium alloys for cases for solid-propellent rockets ; F. Wolff and T. Siuta (Walter Kiddle and Co.) were concerned with another lightweight material for this service—filament-wound fibreglass laminates. They described new testing methods and the factors affecting service life of spherical vessels made from this material ; the data are thought to be applicable to other rocket components.

In the vacuum of space, a satellite or vehicle cannot lose or gain heat by conduction or convection, so that all heat transfer must be by radiation. The design engineer must have information on the thermal emission characteristics of materials, especially coatings, but the data are meagre and incomplete. S. Heilveil and P. Fischer of the General Electric Company have made a spectrographic study of the absorptance and emittance of a variety of materials ; they state that they have recorded over 2000 spectra, but they only give a few typical results, which considerably reduces the value of the paper. The emittance of buffed aluminium is only 0·013–0·018, whereas coloured anodised aluminium shows values of 0·74–0·78, white paint 0·79, and carbon black paint 0·83.

Other materials papers included " Performance Evaluation of the Types of Tungsten Used in Solid Rocket Nozzles," by A. V. Levy and S. E. Slosarik (Aerojet-General Corporation) ; " Fabrication of Thin Wall Tungsten Liners for Solid Rocket Motors," by R. E. Anderson and F. L. Banta (Aerojet-General Corporation) ; " Erosion Parameters Affecting the Performance of Graphite Rocket Nozzles," by L. M. Swope (Aerojet-General Corporation) ; " Characteristics of Energy Absorbing Material for a Lunar Soft Landing Vehicle," by M. Feigen, G. Fitzgibbon and E. Burchman (Space Technology Laboratories) ; and " The Liquid Range of Metals and Some of Their Physical Properties at High Temperatures," by A. V. Grosse (Temple University).

Associated with these were several papers on structures. Paul Seide and V. I. Weingarten (Space Technology Laboratories) employed the theorem of minimum potential energy to solve the problem of determining the buckling under uniform external pressure of circular rings and long cylinders enclosing an elastic material. The particular problem of interest is of course that of a casing filled with solid propellent. The numerical results indicated that the buckling pressure is significantly increased even for relatively flimsy cores. " Weight *vs* Reliability : A Design Choice," by M. E. Alper (Jet Propulsion Laboratory) took as example the design of a waste heat radiator for nuclear-electric powered spacecraft. H. N. McGregor (Martin Company) reported on tests to investigate the fatigue failures induced acoustically in missile structures and equipment during in-silo launch. In general, most components are relatively insensitive to direct acoustic excitation up to sound pressure levels of 160 dB ; component vibration levels due to acoustically induced structural vibrations are higher than levels occurring during above-ground launch, and generally require vibration protection of the component.

" Isotensoid Pressure Vessels," by John Zickel (Aerojet-General Corporation) developed design equations for filament-wound vessels, no strength being attributed to the resin used as binder. A. P. Coppa (General Electric Company) compared various types of impact landing system that might be used for lunar landings : pneumatic bags, collapsible struts, foams and honeycombs, collapsible shell structures, and long spikes. The excellent energy absorption and stroke properties of the collapsible shell device makes it ideal for terminal deceleration of space vehicles and General Electric have been doing research on this. The shells were of 2024 T-3 aluminium alloy thin sheet and the effect of bleed and non-bleed pressurisation was studied ; only vertical landing was considered. In the exposition a demonstration was given to show the high degree of orderliness in the collapsed shell.

A group of papers dealt with re-entry thermal problems ; they were : " The Aerothermo-Viscoelastic response of an Orthotropic Material during Hypersonic Flight," by S. M. Scale, E. J. Nolan and A. M. Garber (General Electric Company) ; " Critical Aero-Thermodynamic Parameters in Thermal Protection Design of High-Performance Re-entry Bodies," by H. Hurwicz and J. D. Brown (Avco Corporation) ; " Thermal Protection of Satellites with ' Cold-Wall ' Ablation," by H. Hurwicz and R. Mascola (Avco Corporation) ; " Advances in Thermal Insulating Materials for Thermal Protection Systems," by P. E. Glaser (Arthur D. Little Inc.) ; " Vapour-Cooled Insulation for Thermal Protection of Hypersonic Glide Vehicles," by W. D. Allingham (Boeing Company) ; and " Thermal Stress Analysis of Re-entry Structures with Multiple Corrugated Webs," by F. C. S. Hung and D. J. Stone (North American Aviation).

Nuclear Rockets.—" Throwaway " chemical and nuclear propulsion systems were compared by S. V. Gunn and A. Negro (Rocketdyne Division of North American Aviation) on the basis of cost, mission flexibility and reliability. They showed that incorporation of a nuclear rocket engine into one or more upper stages of the currently planned " Saturn " and " Nova " vehicles was desirable because of the increased payload capability and decreased unit payload cost.

Jerry Grey and D. L. Chubb (Princeton University) showed that it would be feasible to achieve supersonic heat addition in the nozzle of solid-core nuclear rockets ; such addition can more than double the specific impulse. The heat addition is achieved not through atom recombination but through augmented turbulent heat transfer from a heat-generating solid.

A method for determining the optimum nuclear powerplant parameters and the results of one such analysis were presented by P. G. Johnson and G. R. Cowgill of N.A.S.A.'s Lewis Research Centre. The interplanetary missions are assumed to start from a low-altitude earth orbit. Initial nuclear-stage mass and mission velocity requirements are varied over wide ranges, and for each combination optimum values of reactor-exit hydrogen pressure, reactor flow area and reactor length are calculated. Reactor diameter and mass are determined from criticality studies. Reactor heat-transfer and pressure-drop correlations are obtained from an analysis which includes power distribution, multiple-passage effects, thermal radiation, dissociation, &c. Nozzle cooling is incorporated by balancing gas-side and coolant-side heat fluxes at the throat for a specified wall temperature. Turbopump mass is a function of pump horsepower. Vehicle-component masses are functions of propellent or stage masses. Another paper from the Lewis Research Centre (by H. M. Henneberry and R. J. Lubick) considered the application of nuclear rocket engines to manned lunar missions.

Three engineers from the Douglas Aircraft Company (R. W. Hallet Jnr., W. E. Matheson and R. F. Trapp) spoke on the Reusable Interplanetary Transport Approach to Space Travel (R.I.T.A.). They estimate that the cost of delivering cargo to the Moon (dollars per pound) using a two-stage nuclear propelled vehicle can be only two to twenty times (depending on the specific impulse developed) that with a DC-8 aeroplane on a 12,000 mile mission. With a single-stage vehicle, the cost would be much greater at specific impulses less than 1100 lb wt/sec/lb. Three vehicle designs are proposed : a test vehicle (R.I.T.V.) to be launched from a " Thor " missile, " Rita-A " using the heavy nuclear engines which will be available initially, and " Rita-B," having a reactor thrust of 1,500,000 lb. It is suggested that these could be ground-launched using the nuclear engines without any great hazard ; unprotected personnel should be able to enter the launch site within fifteen minutes after launch. There would be a shielded well into which the three crew couches could be lowered, and cargo would be carried above the cabin. Cargo unloading would be by a boom hinged at the vehicle base and extending up the side of the vehicle to a

door and unloading cage ; cage and boom would be lowered by a cable and hoist.

The provision of a shielded well is desirable not only because of the use of a nuclear engine but also because of the hazard in passing through the van Allen radiation belts that surround the earth or in being in the path of solar radiation during active (flare) periods. If one could accurately predict these periods, the shielding could be reduced considerably. B. E. Thompson, J. H. Guill and H. Radd of General Dynamics/Astronautics have made a design study of a solar monitor spacecraft which would be capable of close-in observation of the Sun to provide warning of what is happening on the side hidden from the earth. The monitor would be nuclear-propelled and fitted with a solar power supply.

H. Radd and I. J. Deane of General Dynamics/Astronautics discussed the significant elements in a nuclear rocket development programme leading to flight testing and indicated the associated facilities which are required. C. E. Walter and W. C. Miller (Lawrence Radiation Laboratory) described actual test facilities for nuclear ramjet reactors (" Pluto " and " Slam " programmes) ; J. E. Van Hoomissen (General Electric Company) those for high temperature reactors ; H. T. Gittings and C. F. Fenstermacher (Los Alamos Scientific Laboratory) those for the " Rover " nuclear rocket engine. H. Biederman and P. Paskert (Lockheed Aircraft Corporation) gave an economic justification for developing the nuclear engine, but pointed out that this was somewhat academic as President Kennedy and N.A.S.A. had already announced nuclear propulsion development as a national goal.

Project " Pluto " just referred to has as its objective the demonstration of the feasibility of a nuclear reactor capable of propelling a supersonic ramjet missile. At this stage of the programme only ground tests are possible, stored air being used for cooling the reactor, so that tests are limited to a period of several minutes. Two reactors have been developed at the Lawrence Radiation Laboratory. " Tory " II-A was successfully tested at intermediate power levels in May, 1961, at the Nevada Test Site and is now undergoing advanced testing. It is to be followed by " Tory " II-C, a full-scale missile-like reactor with control rods inside the core. Control systems for both reactors were described by R. E. Finnigan and C. G. Nelson, who also mentioned the control problems which would be encountered in designing an actual flight engine.

These problems are formidable and eventually it may be found that although a ground engine can be built, the nuclear ramjet is unsuitable for use in missiles, repeating the experience with the nuclear aircraft gas turbine.

S. Singer (Los Alamos Scientific Laboratory) reported on automatic control systems for the " Kiwi-B " reactor forming part of the Project " Rover " for a nuclear rocket engine, and A. R. Gunion and R. Winn discussed the neutronics system for this project, embodying equipment for external measurement of the neutron flux and decision-making logic system capable of shutting-down the reactor in the event of a serious malfunction.

Exposition

The exhibit area occupied 95,000 square feet of floor-space. Some of the larger firms used what was claimed to be a new exhibiting technique, namely " Exhibiting in Depth "—use of booth space on both sides of an aisle rather than the standard arrangement along a single side or as a block. This was intended to remove the distraction to attendees of booth-facing-booth competition.

Fig 2—A full scale model of the Orbiting Astronomical Observatory, with two of the four banks of solar cells in the foreground

The principal area, immediately facing the escalators from the foyer to the first floor, was that occupied by N.A.S.A. and the Department of Defense. The focal point of this display was a large globe of the earth around which were coloured plastic rods depicting the initial orbits of all the satellites (U.S. and U.S.S.R.) launched to date. Around the " plinth " beneath the globe were illuminated glass panels, each corresponding to one of the major satellites or a series of satellites. In addition to a picture, its characteristics and performance were given. Nearby on a large " scoreboard " were tabulated pertinent data on all satellites which had achieved orbit (this was an abbreviated version of the scoreboard kept at the N.A.S.A. Goddard Space Flight Centre, seen by the I.A.F. delegates when they visited at the end of the Congress). The other half of the N.A.S.A. display was dominated by a Project " Mercury " capsule, fitted with transparent panels so that the interior could be inspected (other Project " Mercury " capsules were shown on the McDonnell Aircraft Corporation stand, in Times Square, and—on top of a " Redstone " rocket—in Columbus Circle outside the Coliseum).

The N.A.S.A. display also featured the capsule of " Discoverer " XIV which had been recovered from orbit and a full-scale " Ranger " lunar satellite. The latter was on view for the first time ; " Ranger " 1 was launched on August 23, 1961, from the Atlantic Missile Range. The identical " Ranger " 2 is soon to be launched ; the primary purpose of " Rangers " 1 and 2 is to develop and test the basic elements needed for lunar and interplanetary missions. " Rangers " 3-5 will be sent to the Moon ; they will send back readings from gamma-ray spectrometers, take successive photos of the lunar impact area, and place a capsule containing a seismometer and transmitter on the lunar surface. " Rangers " 6-9 will send back high-resolution T.V. pictures of the Moon.

On this stand were several large models of satellites and space vehicles, including an " Apollo " three-man laboratory mounted on a " Saturn " rocket, the " Surveyor " lunar satellite, the " Nimbus-Aeros " weather satellite, a second stage for the " Titan " rocket, a nuclear-powered space vehicle under development by the Lewis Research Centre, and the " Snap " 2 auxiliary power system.

The stand of the General Electric Company featured several large nose-cones which had been recovered from re-entry vehicles. That of the Radio Corporation of America had models of the " Tiros " and Project "Relay" satellites together with a magnetic field simulator which had been used to test the " Tiros " II and III weather observation satellites. This was a spherical cage designed to produce magnetic fields resembling those of the earth, so that the magnetic orientation system of the satellite (placed inside the cage) could be checked.

Grumman Aircraft Engineering Corporation had a full-scale mock-up of what will soon be America's largest satellite—the Orbiting Astronomical Observatory (Fig. 2). This will be the world's first large telescope in space ; the intended orbit is at an altitude of 500 miles, where it will circle the earth

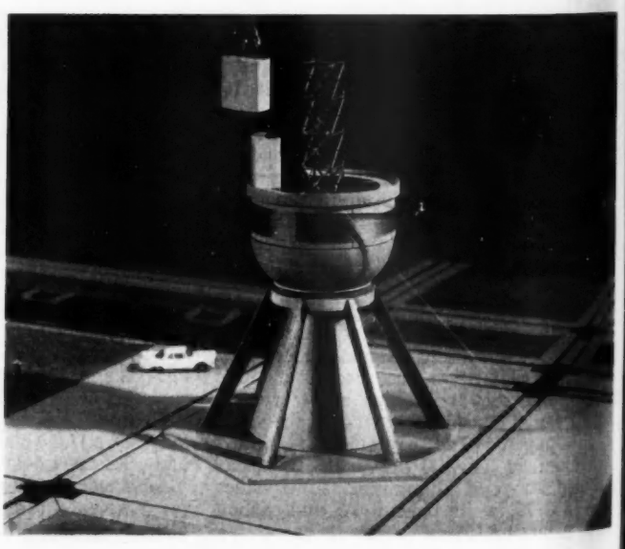


Fig. 3—Proposed booster of 20,000,000 lb thrust for two minutes seen in model form. Solid propellant segments are positioned within an adapter band of 38ft diameter on the completed nozzle. Each completed row is secured with circumferential winding of resin-impregnated glass fibre. The adapter band is then moved up so that succeeding rows or segments can be positioned

once every 101 minutes. It is provided with an automatic sunshade to protect the optical equipment inside from direct sunlight.

The data processing system for O.A.O. was featured by I.B.M. Federal Systems Division, who also demonstrated a memory system cooled to −434 deg. Fah. by liquid helium, and the guidance computer for "Titan" II.

United Technology Corporation had a full-scale mock-up of the 200,000 lb thrust solid-propellent engine which had been successfully fired (nose down) for eighty seconds. They also had scale-models of proposed large solid-propellant boosters. These were the Pl-5 a five-segment, 330,000 lb propellent motor, developing 1,000,000 lb thrust for eighty seconds, and the Pl-10, containing ten segments (880,000 lb propellent), 180ft high, and developing 2,000,000 h.p. for eighty seconds. The company have also proposed a cluster of seven segmented boosters; this should develop 11,000,000 lb thrust for eighty seconds.

Others firms also declared their ability to construct large solid-propellent boosters. Thiokol Chemical Corporation were advocating a 28ft diameter booster to take the place of the liquid-propellent "Nova" rocket that is still on the drawing board as a successor to "Saturn." To illustrate its size a quadrant mock-up of the full-size section was mounted vertically adjacent to two mirrors in perpendicular planes, so that the observer saw a complete 28ft diameter circle with star centre. The Hercules Powder Company had models to illustrate how a similar solid booster could be built *in situ* from blocks of solid propellent placed around a removable former. A working model (Fig. 3) demonstrated how the motor would then be wound up with glass filaments, one set of bobbins winding circumferentially, another diagonally. In practice the filaments would be coated during winding, and this would be cured *in situ*.

Large liquid-propellent motors were also represented. North American Aviation Inc. showed full-size mock-ups of the engine bay of the "Saturn" first-stage and of the 1,500,000 lb thrust F-1 engine which could find application in the "Nova" rocket, if it is eventually decided to proceed with this. This company also demonstrated a satellite orbit computer consisting of five graduated Perspex discs, map and scale. Another exhibit was a model of a proposed lunar base facility.

Several exhibitors attracted interest by including "space games" on their stands. Thus Sperry Rand Corporation had one in which a missile had to be launched to intercept a satellite. The latter was a light moving round behind a glass panel bearing a map of the world; an illuminated missile at Cape Canaveral turned round at a different rate, and when a button was pressed it spiralled out, hitting the "satellite" if the angle at launching had been correct. General Dynamics had a variation of this in which a steel ball representing a space vehicle had to be shot from a central rotating earth out to hit a model of the Moon revolving at a different speed (Fig. 4). The ball travelled out over a rubber disc moulded to represent the gravitational field of the earth; here again, it was necessary to choose the correct moment for pressing the "launching" button. General Dynamics also had several "aptitude tests" for potential astronauts.

Space Technology Laboratories had several exhibits, including an image converter camera operating with exposure times of 10^{-9} seconds. This was used for taking photographs of ion sources. There were also models of hydrogen/oxygen fuel cells for a manned space vehicle, a 60W solid propellent turbo-electric power system, and the "Sunflower" 3kW solar mercury Rankine cycle power converter (one-twelfth scale). A full-scale model of the "Snap"-2 3kW power unit being developed jointly with Atomics International Division of North American Aviation was also included.

Luncheon Addresses

Addresses were given at the luncheons each day. Dr. W. H. Pickering, Director of the Jet Propulsion Laboratory, California Institute of Technology, referred to the increasing number of meetings being held and the proliferation of scientific societies. It had been estimated that the attendance of engineers in the U.S. missile and aerospace industry was 100,000 man-meetings per year. Time and travel costs averaged 500 dollars per man-meeting, but attendance at first-class meetings could pay for itself many times over. The inferences were that firms should only send their staff to first-class meetings (such as *Spaceflight Report to the Nation*), and that if the A.R.S. could further improve its quality it would be contributing directly to the national interest.

The relation between the universities and the U.S. national space programme was discussed by Professor James A. van Allen. He thought that many more universities should participate in this programme—the number which had already done so could be counted on the fingers of both hands. There was a lack of fundamental literature in this field, but unfortunately many practitioners exhibited only the most superficial familiarity with such literature as does exist.

James E. Webb, Administrator of N.A.S.A., outlined the policy adopted in planning the U.S. space programme. General B. A. Schriever, Commander of the Air Force Systems Command, said that space offered certain advantages as a medium for military operations and the nation that dominates space might—if it chose—dominate the world. In order to operate effectively in space the United States would need a mix of unmanned and manned space vehicles. The key to rapid utilisation of space by man for military purposes was flexibility. Space vehicles and programmes must not be designed to achieve just those objectives which could be defined now. The vehicles must be designed with enough capacity to rapidly adapt or to incorporate the vast new knowledge which would flow from the space programme. The accomplishment of the Manned Lunar Landing Programme and the development of manned military space systems are both of vital importance to the ultimate survival of this nation and the rest of the free world.

Dr. Simon Ramo (Executive Vice-President of Thompson Ramo Wooldridge Ltd.) criticised industry-government relations. He entertained his audience with an amusing account of what would happen in school if marks were given and promotions gained by the same system as contracts are awarded by the U.S. government. He suggested that the criterion should be past performance rather than promises of future performance.

At the banquet held at the Waldorf-Astoria over 1000 guests heard an address by the Honourable Lyndon B. Johnson, Vice-President of the U.S.A.; this was also broadcast nationally. He began by saying that one of the major problems confronting America's space effort stemmed from the government's own rules, which prevented it from competing for talent with private organisations. All too often, the government space installations were training grounds for the highly paid technicians and vice-presidents of private industry.

He again called upon all members of the United Nations to establish a far-ranging rule of law for outer space. As a servant of peace, a satellite could give incomparable service in helping us to interpret, and ultimately perhaps to control, weather conditions; it could link nations in a swift system of communications; it could help keep the peace (a single satellite could bring all the varied traffic on the Atlantic or Pacific Oceans under constant observation). But as a weapon of intimidation or blackmail space vehicles could bring dangers of a new or sinister kind.

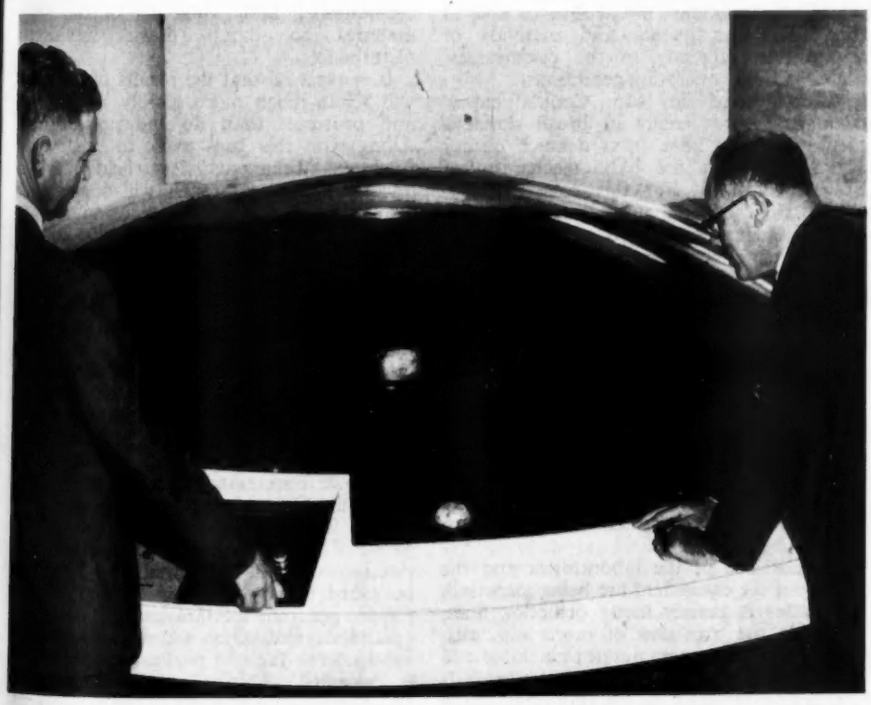


Fig. 4—Earth-to-moon fall simulator: notice the relative shallowness of the moon's gravitational field

The appropriations for the U.S. space programme had been increased by 50 per cent, requiring an expenditure of 2500 million dollars, and this figure would rise in coming years. A practical and advanced communications satellite could be achieved in the near future. The development of such a system into a global network would be encouraged.

The second stage would involve the direct transmission of f.m. programmes to home receivers ; in this stage it would be possible to broadcast news and concerts from the U.S.A. to all the world. In time this could lead to the development of a world-wide direct television network.

In concluding, the Vice-President said that if he could get but one message to his audience it would be simply this : the future of their country and the welfare of the free world depend upon America's success in space.

Carbon Brush Conference

A conference on carbon brushes attended by a number of users was organised by Morganite Carbon Ltd. in London last month. The papers presented at the conference indicated some of the ways in which this company is using fundamental research, laboratory tests and field trials and correlating them with the general aim of being able to give precise predictions of brush performance. A short résumé of the proceedings is given below.

A THREE-DAY conference on carbon brushes, organised by Morganite Carbon Ltd., Battersea Church Road, London, S.W.11, was held in London last month. It was attended by 120 delegates who formed a representative cross-section of carbon brush users in this country and overseas. It was the first conference of the kind to be organised by a member of the Morgan Crucible Group and it offered a useful forum for the interchange of information and ideas about carbon brushes.

The proceedings began with introductory talks by Mr. C. S. Harris, managing director, and Mr. F. K. Earp, technical director, of Morganite Carbon Ltd. The main part of the programme consisted of the presentation and discussion of papers[1–11] dealing with various aspects of the Group's efforts devoted to research and development work on carbon brushes and brushgear. As a background to these meetings there was an afternoon tour of the Group's engineering and research laboratories.

The company proposes to publish the full proceedings of the conference.

Aims of Brush Development

Some of the main properties demanded of brushes for commutator or slipring machines as discussed in one of the conference papers[1] are: (1) Good commutation, generally over long periods; (2) Good current collection; (3) Long brush life; (4) High strength or toughness; (5) Low losses and temperature rise; (6) Heavy overload capacity; (7) Quiet running; (8) Ability to form a commutator skin quickly in adverse atmospheric conditions; (9) Low commutator wear.

As pointed out in this paper[1] not all of these properties are required by all users. In any case it is a manufacturing impossibility to do more than aim at some specific compromise between these properties, since some of them are to some extent mutually incompatible. For example, the manufacturer of low-voltage machines prefers a brush which gives the lowest losses and, therefore, the highest machine efficiency. On the other hand the ultimate user is often more interested in minimum commutator wear and maintenance and long brush life. Quiet running is important for only a limited range of machines, mainly gramophone motors and passenger lift motors. Mechanical strength is important in traction motors. A nice balance of coefficient of friction and contact drop is needed to provide high machine torque in many accessory motors on automobiles. Most machine users want the longest possible brush-life, whereas on some applications such as torpedo motors, with an operating life measured in minutes, brush life is immaterial.

Accordingly the brush maker must be prepared to cater for a wide variety of combinations, in various degrees, of the properties enumerated above. To meet these requirements a prodigious variety of products is possible as a result of differences in the constituents and in the processing conditions of carbon brush materials, as stated in the introductory lecture given to the conference by Mr. A. E. Feaver. For example, of 10,000 trial mixes investigated by this company 700 have proved to be useful in practice.

Research, Development and Evaluation

The ultimate aim of the brush maker (which can be equated with the ideal sought by the user) is to be able to predict the precise effect of all the variables in manufacture and operating conditions: in effect to be able to relate the constituents and methods of manufacture, directly to the performance under specified operating conditions.

As suggested in Mr. Cook's paper[1] dramatic improvements in brush development can only arise from a much clearer understanding of the basic mechanism of brush operation. For this reason fundamental work on commutation is now going on and sustained effort to analyse all the various parameters in brush operation is being made.

The immediate research programme now being mounted in Morgan Research and Development Ltd. and Morganite Carbon Ltd. includes three main lines of attack as described in Mr. A. G. Conford's paper[2] :

1. To improve laboratories and testing methods.
2. To devise new and more direct methods of test.
3. To improve methods of field evaluation.

Laboratory Improvements.—These take two forms.

(*a*) The size of the laboratories and the variety of the equipment are being increased. The latter is mainly along orthodox lines, including the provision of more m.g. sets, slipring machines, commutator machines and friction and contact drop machines, as detailed below under the heading Engineering Laboratory.

(*b*) At the same time more emphasis is being placed on relevance between laboratory test results and field experience. For example, on laboratory motor-generator commutation tests, a schedule has been established which shows up high-speed electrographitic grades of carbon in the right order with respect to collection/commutation ability and commutator skin formation.

Test conditions necessary include light spring pressures and high current densities not representative of operating conditions for the machines used. The justification for this simplification is that the service conditions impose demands on the brushes which have the same effect on them as do light pressure and heavy density on the laboratory machines. The first approach therefore to any laboratory test by Morgan's is to evaluate a variety of grades whose performance in the field is well known ; not until relevance is achieved is the test used in the evaluation of new grades.

New Methods of Test.—The approach here is an extension of that just outlined. Using simple test gear, test schedules are being devised which will evaluate one particular facet of brush behaviour. Initially, the work concerns such things as contact drop/current density, friction/speed, wear/current density, wear/pressure, surface glazing, spark puncture strength, etc. At present this programme is devoted to the development of the actual test methods. Part of this exercise is to explore the relationship of test gear size to results, in the hope that the ultimate pattern may be the use of large numbers of small machines.

Associated with this programme is the work being done by Mr. A. F. Watson[3–4]. This is an exploration of the relationship between such simple tests and the fundamentals of brush behaviour (rather than the normally accepted criteria). For example, brush performance is often specified in terms such as commutating ability, stability, life, etc., but these aspects of behaviour are the result of more fundamental factors such as (*a*) the influence of the brush characteristic in reducing reactive voltages in a coil subject to current reversal ; (*b*) susceptibility of the brush frictional behaviour to mechanical oscillations ; and (*c*) ability of the brush material to damp down mechanical disturbances.

It is expected that the results of this work will relate much more closely to materials and processes than do the present tests. Along with this goes work to relate these fundamental characteristics to field behaviour. Success in this approach will simplify the evaluation of grades by interposing only one link, i.e., simple fundamental tests, between materials and processes on the one hand, and operation on the other.

Improved Field Evaluation.—While the company is pursuing the above developments, the time scale may be long and, in the interim, it will be necessary to continue to rely on field testing to assist development. This work is of course supplementary to field tests intended to solve a specific brush problem and will involve increased co-operation from manufacturers and users in mounting tests of experimental grades of carbon which will have passed through the gamut of laboratory tests, so that therefore the risk involved will be minimised. Users will be asked to co-operate in tests which will require accurate specification and control of conditions, and which will not always result in success so far as a particular machine use is concerned. This policy of field evaluation has of course been pursued for many years, but recently on a much more planned basis.

The ultimate objective of this evaluation work is an ideal in which brush grades may be selected on the following basis. Each brush grade will carry a rating for each of many fundamental operating characteristics. Required machine performance under given conditions will be specified in terms of these fundamental criteria. Comparison with the ratings of various grades will enable the correct selection to be made. At the same time the work of the development chemist will be greatly eased as exact relationships will be built up between materials and processes and the fundamental tests. It is appreciated that this ideal may not be fully attained but the planned approach to it will benefit both the user and the manufacturer.

Engineering Laboratory

It was in 1903 that the first tests were carried out in the company's Battersea works on electrical machines equipped with brushes cut from Plumbago crucible material instead of the copper gauze brushes then in use. Later the advantages of carbon over plumbago were established and a new department was formed to develop and manufacture carbon brushes. By 1912 a number of grades had been introduced and their properties assessed on production machines both at Battersea and in the field.

The company's first brush test equipment was installed in 1912 in a small electrical labortory staffed by two people. There existing grades of brush material were investigated for electrical conductivity, current collection, contact drop, friction and wear. Brush flexible connections were also studied.

Today the engineering laboratory occupies a floor area of 18,000 square feet, and employs a staff of about 60, serving the needs of the following departments : production, process control, development, inspection and application.

Friction and Contact Drop.—Measurements of the coefficient of friction and of the contact voltage drop constitute the basic running test for carbon brushes. A knowledge of these properties and their dependence on running speed and current density provides a useful initial sorting test for development materials and a reliable control test of standard production materials.

The laboratory contains about thirty friction and contact-drop machines each consisting of a slotted copper collector system driven by a d.c. shunt motor controlled by field and armature rheostats. The standard collector is about 9in in diameter and carries four brushes connected as two parallel pairs in series with the ring and the power supply. All the brushes run on the same track and can be tested and assessed over a range of current densities, peripheral speeds and spring pressures.

The coefficient of friction is calculated from the measured difference between the power absorbed in the armature circuit of the driving motor with and without the brushes on the slotted copper ring. In each case the armature voltage and the speed of rotation are kept constant and a correction is made for I^2R losses in the driving motor armature circuit. Normal measurements are taken on a fully-developed collector surface at the specified conditions, though much useful information can be gained on the possible general performance of the brush material by taking observations during the bedding period.

Measurement of the contact voltage drop is done on all four brushes by the simple method of probes connected through a voltmeter placed on the brush terminal and the collector ring.

Still further conclusions can be drawn from the relationships between the coefficient of friction and peripheral speed, and between the contact voltage drop and current density[3,4].

To a first approximation both of these relationships follow logarithmic laws of the form

$$F = AV^{-S} \quad . \quad . \quad . \quad . \quad . \quad (1)$$

where

F=coefficient of friction, V=velocity, A and S are constants,

$$V = CI^{M} \quad . \quad . \quad . \quad . \quad . \quad (2)$$

where

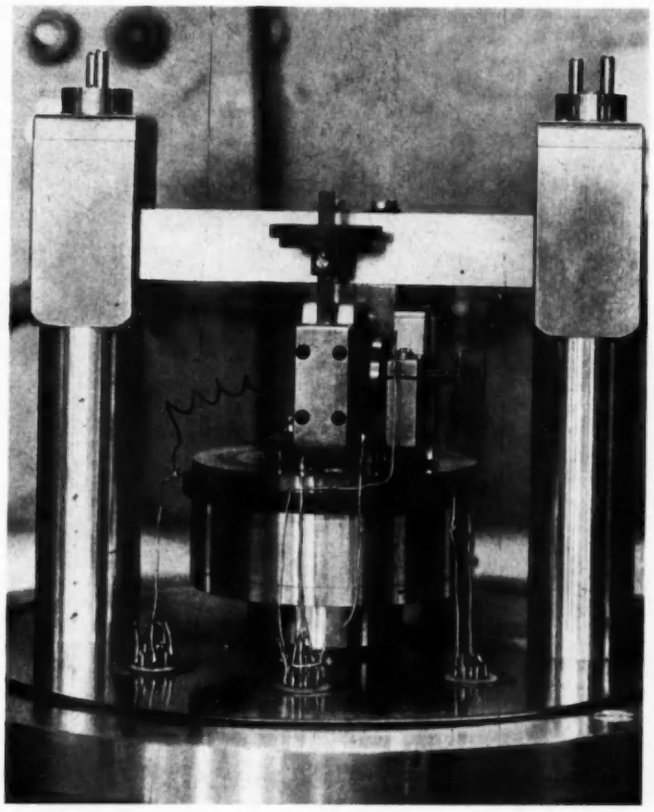
V=Contact voltage drop, I=current density, C and M are constants.

Generally the knowledge of the constants of equation (1) enables a prediction to be made on susceptibility to glazing, chatter, etc. Knowledge of the constants in equation (2) gives valuable information of the ability of a material to handle reactive voltages in d.c. machines, and rotational and transformer voltages in a.c. machines.

Standard friction and contact drop machines of the type described are being employed in the Laboratory on investigational work aimed at increasing knowledge of the mechanism of the interface[5], and enabling brush grade selection to be made by reference to physical properties and simple assessment tests. A comprehensive series of tests is being made to investigate thoroughly such effects as : the stability of the interface impedance ; the effect on friction and contact drop measurements of ring diameter ; the effect on friction and contact drop measurements of brush section ; and the effect on friction and contact drop values of ring temperature. Standard machines are also being used to determine the effect of load cycling on brush grades and the resistance to glazing under low load conditions.

As it is seldom possible to carry out brush grade evaluation tests under actual operating conditions, and the correlation of simple test data to field performance plays an important part in the effective functioning of the laboratory.

Brush Wear.—Brush wear under controlled conditions is studied in the Applied Research and Development Laboratories and the development of special techniques for this work was described in one of the conference papers[6]. Since typical rates of brush wear are of the order of 1 micron per hour high sensitivity methods of measurement are needed to keep the duration of tests within reasonable limits. One method developed by Morgan's makes use of an a.c. bridge to measure the capacitance between an electrode mounted near the face of the test brush and the copper slipring. Changes in brush length of 0·2 microns can be detected. The electrode and some of the connection leads can be seen in the centre of the accompanying illustration in the space between the brush holder and the cylindrical slipring carrier. The brush holder is suspended from a " bridge " structure and is mounted on a crossed spring to prevent tipping as the block is displaced by friction forces. Controlled humidity is provided by enclosing the mechanism in a bell jar.



Apparatus for measuring the wear of carbon brushes under controlled conditions. Brush wear is measured by a capacitance electrode mounted near the brush face and connected to an a.c. bridge

Sliprings.—Difficulty is experienced in relating laboratory tests on slip ring brush grades to field performance, because of changing requirements, and the variety of slipring material commonly used. One aim of the laboratory is to be able to relate basic information obtained on small ring test equipment to larger machines.

Equipment which has provided a useful control test in the past is made up from a series of rings on a common shaft driven by a d.c. motor. Two such sets are used in the laboratory, each having twelve rings of about 15in diameter, 1·15in wide. The normal peripheral speed of the ring is 4,500 feet per

minute and each ring carries a maximum of four brushes. Connections are made between adjacent rings alternating with connections between adjacent sets of brush gear to ensure equal current through each ring. Current densities used are 83A, 111A or 167A per square inch depending on the material under test.

The machine used for test "control" utilises plain rings of sand-cast bronze. On the other machine are mounted four groups each consisting of three centrifugally-cast rings in cupro-nickel, plain and spirally grooved, and in gunmetal, plain and spirally grooved. On this second machine, datum work is in hand to establish schedules which will reproduce present day field performance of brush grades and ring materials.

Investigational work is also being carried out on a series of machines carrying induction motor sliprings of 5in diameter $\frac{11}{16}$in wide. The rings carry two brushes per ring of $\frac{5}{8}$in by 1in section and ring materials are cupro-nickel and gunmetal. Once again the main object initially is to determine test schedules which are sufficiently severe to show up the variations experienced in the field.

The assessment of grades for operation on the larger sliprings as used in turbo-alternators is carried out on a grooved steel ring of 26in diameter, with peripheral speeds of the order of 15,000 feet per minute.

Atmosphere Testing.—Specific investigations have been carried out in the laboratory on the effect of a variety of atmospheres on brush grade performance, using dummy commutators installed under bell jars in which the specified conditions are produced.

For example work has been done on brush performance in atmospheres simulating high-altitude conditions. Such conditions are produced in a bell jar by drawing air through a refrigerator and drying system into the jar and evacuating to various pressure conditions. The bell jar houses two dummy commutators with brush gear on a common driving shaft so that on each test a standard material can be compared with the material under test. A first assessment of brush wear on each commutator can be made by dial gauges contained in the bell jar and full instrumentation gives knowledge of atmospheric conditions existing in the bell jar during the test.

Brush grades suitable for operation under high-altitude conditions have been developed in this equipment, being mainly grades with additives or cores of lubricating materials such as molybdenum disulphide. The test apparatus is now mainly used for quality control. Complete machines such as aircraft rotary transformers, and inverters can be tested in this equipment.

Similar apparatus has been used to evaluate brush grade performance in silicone atmospheres. This investigation springs from the use of silicone varnishes for the insulation of large machines with high working temperatures: in totally enclosed machines the evolution of silicone vapour causes excessive brush wear. Atmospheres have been created by boiling ethyl silicate in the bell jar and a range of different brush materials has been investigated.

Work is now in hand for the investigation of brush performance in atmospheres of hydrogen and hydrogen sulphide.

Electronics.—Increasing use is made of electronic equipment to help laboratory investigations. For example, brush spark indicators have been developed. They consist of a high-pass input filter with negligible pass band below 100 kc/s followed by an amplifier, detector and metering circuits. The majority of energy associated with brush sparking is usually of a higher frequency than that arising from segmental interruption of the load current. The latter is removed by the filter and the meter reading therefore indicates spark intensity. It is usually necessary to carry out some form of calibration of these meters by visual and oscilloscope methods before use on any given machine.

The profile indicator used in the laboratory is essentially a high-frequency capacitance bridge circuit, one arm of which terminates in a probe which is placed near the surface of the commutator or slipring under investigation. The bridge is balanced at one position, and is thrown out of balance by changes in the capacitance between probe and surface due to changes in the profile of the surface. The out-of-balance signal is normally displayed on an oscilloscope.

A special oscilloscope has been developed in the company for investigation of brush potentials. It permits examination of the waveform of the voltage drop from brush to commutator over a complete revolution or part of a revolution: the time base is "panchronised" to the rotating machine so that the sweep duration is automatically locked to the speed of the machine, regardless of fluctuations. Synchronisation is obtained by a photocell and light source mounted close to any rotating part of the machine, to which is attached a narrow strip of tape, giving one pulse per revolution to initiate the sweep. "Panchronisation" is obtained by integrating a small portion of the time base sawtooth wave form and feeding back the resulting potential in such a way as to control the sweep velocity.

An example of the original work being carried out is an investigation into brush arc of contact[7]. The apparatus used consists essentially of a special collector in which is mounted a thin strip of copper, flush with its surface but insulated from it. The strip is connected to a slipring mounted coaxially at one end of the collector and a similar slipring coupled to the collector at its other end. A d.c. potential is applied through a resistor between the sliprings, and current flows only when a test brush is in contact with the copper strip. The voltage pulse developed across the resistor is fed to an oscilloscope for examination and interpretation to give the brush arc of contact.

Commutation.—The commutating ability of high speed electrographite grades is assessed on four Metropolitan-Vickers m.g. sets installed in the laboratory. The sets are made up from two identical machines 115V d.c., 225A, 2000-2500 r.p.m. coupled back-to-back, and a 12 h.p. driving motor mounted on a common bedplate. The two test machines are shunt-wound separately-excited by four poles with interpoles, and interpole strength is varied by means of divert-resistors.

Commutation margin recordings are taken under standard conditions, and investigations of overload and overspeed conditions are made at the end of each test. Special tests are also made on these sets to assist development of grades intended to operate on difficult variable-load machines such as rolling mill motors. The test conditions are successively worsened in respect of spring pressure and current density (to simulate brush performance in the field) culminating in breakdown of commutation and collection. A temporary return to easier running conditions enables the "recoverability" of grades to be assessed.

To assess brush grades for use on traction machines an English Electric traction test set has recently been installed. The set comprises two EE507 (700V, 250 h.p.) traction motors connected in a series Hopkinson arrangement together with a circulating booster generator. The machine acting as a generator has its series field excited from a shunt connected generator, and for commutation assessment the interpoles are strengthened or weakened by the use of an auxiliary generator. Suitable switching is incorporated so that direction of rotation can be reversed and the roles of motor and generator can be interchanged. An interesting detail is that search coils have been incorporated in the armatures of each test machine for commutation investigations.

Exact test conditions have not yet been established on this set, but some useful information has already been obtained.

In passing mention should be made of a development which is in hand by Morganite Carbon Ltd., and may have an important influence on the design and construction of rotating electrical machines. It is a commutator segment of composite copper steel construction, combining the good electrical properties of copper on the running face with the good mechanical properties of steel in the main stress-carrying body of the segment. The advantages envisaged from this composite structure are higher speeds and operating temperatures and longer axial lengths of commutator body without the complication of shrink rings. A commutator embodying this idea has been built into an English Electric EE507 traction motor and has already done initial running trials totalling 50,000 miles on the Southern Region system.

An interesting investigation is under way in the laboratory on three machines which have been designed by Morganite Research and Development Ltd. to reproduce artificially the effects of commutation. A special commutator driven by a 1 h.p. induction motor has successive segments in each group of four connected to four sliprings mounted on the same shaft. The brushes running on the sliprings are connected to the junction points of four variable inductors in a bridge arrangement. Direct current is passed via the test brushes to the commutator and hence through the inductors. Commutation conditions are thus produced in coils of variable inductance.

More details of the characteristics and possible uses of these machines were given in one of the conference papers[8].

Two Schräge motors are installed in the laboratory for a.c. commutation assessments. Circulating current losses are estimated on an S. S. W. Schräge motor with a short circuited stator and a rotor with separate d.c. and a.c. windings. The a.c. winding is connected to a multiple tap transformer and the voltage to the sliprings can be varied over the range 55V–550V. The d.c. winding is connected to the commutator, the voltage between segments being dependent upon the slipring volts. The test brushes running on the commutator short-circuit the high-resistance coils of the commutator winding causing circulating currents to flow in them with high loss. These losses are measured at various slipring voltages.

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Notable Locomotives of 1911

By E. C. POULTNEY, O.B.E.

WHEN recalling locomotive developments on British railways during 1911, now half a century ago, several interesting examples are worthy of notice. The year 1911 is to be remembered for the reason that it witnessed the founding of the Institution of Locomotive Engineers, which celebrates this year its golden jubilee. Looking back to 1911, several locomotives claim attention ; further, to single out one as being more important than another must always present some difficulty. However, few would be found to disagree if the new three-cylinder express passenger locomotives of the 4–4–2 type, designed by Vincent L. Raven (later Sir Vincent) for the North Eastern Railway, were considered to be the most notable, especially in view of the large number of three-cylinder simple expansion locomotives subsequently built for passenger traffic on other railways. The fact that J. G. Robinson's three-cylinder engine was the first of this description to be used for fast passenger traffic can hardly be said to detract from the importance of the Raven engines, as it was really only an experimental conversion of an existing standard "Atlantic" and was, moreover, later reconverted to the two-cylinder standard "Atlantic" type.

Passing on to other notable locomotives introduced during 1911, mention may be made of Bowen Cooke's 4–6–0 type locomotives, known as the "Prince of Wales" Class, for passenger services on the London and North Western and others of a generally similar design built by Stephen Holden at Stratford for the Great Eastern Railway.

Further new locomotives demanding notice include Fowler's 0–6–0 superheater fitted goods engines for the Midland Railway, and others also built for freight traffic include J. G. Robinson's 2–8–0 locomotives for the Great Central, a noteworthy design destined to achieve considerable notoriety for themselves and their designer when selected by the War Office for military services overseas during the 1914–18 war. A further Great Central design constituted a large 4–6–2 tank engine built for services in the London district. At Swindon, G. J. Churchward built a new 2–6–0 locomotive intended for general services ; in fact, these engines may be designated as being the first of what could be called mixed traffic locomotives on British lines. They were further distinguished by being among the first to have Churchward's well-known top feed, since then a distinguishing feature of Great Western locomotives. Other locomotives include the introduction of superheated 2–4–2 type tank engines for the Lancashire & Yorkshire Railway and a further four-cylinder 4–6–0 design for the London and South Western Railway, built at Eastleigh by D. Drummond.

It is now proposed to describe in more detail the locomotives mentioned.

NORTH EASTERN RAILWAY

Raven's Three-Cylinder Express Locomotive

Designed at Darlington, the first twenty of these locomotives were built by the North British Locomotive Company, Glasgow, ten being experimentally fitted with Schmidt type flue type superheaters, the remaining ten being non-superheated. Apart from this difference and having cylinders 15½in diameter and a higher working steam pressure of 175 lb per square inch comparing with 16½in cylinders and 160 lb per square inch steam pressure, these locomotives were alike.

Raven reverted to the plan adopted by his predecessor, W. Worsdell, when the two four-cylinder compounds (Smith's system) were built in 1906 (THE ENGINEER, November 30, 1956), by placing the three cylinders in line transversely, as was the case with the four-cylinder compounds, and driving through the medium of the leading axle in the manner initiated when the 4–6–2 three-cylinder tank engines were built in 1910, illustrated in THE ENGINEER of August 12 last year.

The three cylinders with the valve chambers comprised a single casting ; the valves of the piston type (Smith's pattern) were all operated direct by three sets of Stephenson's valve gear. The valves for the outside cylinders were placed inside the main frames alongside their respective cylinders and the valve for the centre cylinder was above the cylinder with its axis inclined downwards, so that direct connection could be made with the valve gear. All six eccentrics were mounted on the single throw crank axle of the Worsdell type, having circular webs which with this pattern of crank axle may be of relatively thin section, thus leaving ample space for the eccentrics while permitting adequate room for the main journal bearings, 10in long by 9in diameter. The valve gear was controlled by a steam operated reversing gear. The valves were set to give a "cut-off" in full gear of 65 per cent.

The boilers for these engines were of the same design and dimensions as used for Worsdell's Class V "Atlantics" of 1903, though in the case of both the superheater-fitted and non-superheater engines the heating

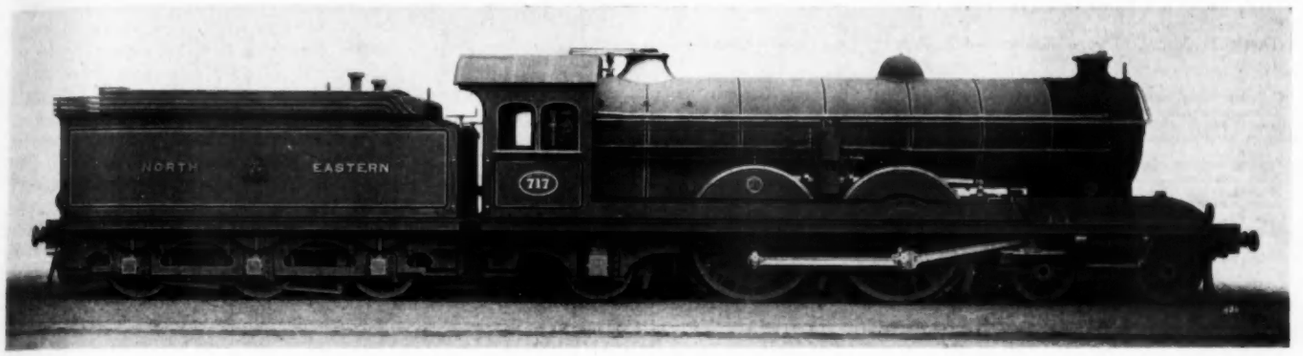
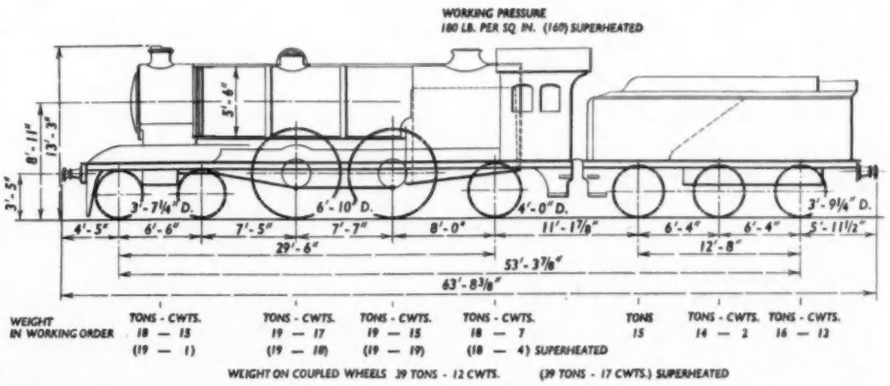


Fig. 1—Three-cylinder express locomotive for the North Eastern Railway (non-superheater)



Gauge of rails	4ft 8½in
Cylinders, three	15½in. diameter by 26in stroke
Heating surfaces, tubes	2160 square feet
Heating surface, firebox	180 square feet
Total	2340 square feet
Grate area	27 square feet
Tank capacity	4125 gallons
Fuel capacity, 5 tons	225 cubic feet
Total weight of engine in working order	76 tons 14 cwts.
Total weight of tender in working order	45 tons 15 cwts
Total weight of engine and tender in working order	122 tons 9 cwts.
Tractive force at 75 per cent of working pressure	15,424 lb

L437 (Superheated)

Gauge of rails	4ft 8½in
Cylinders, three	16½in diameter by 26in stroke
Heating surface, tubes	1799 square feet
Heating surface, firebox	180 square feet
Evaporative total	1979 square feet
Superheater	530 square feet
Total	2509 square feet
Total weight of engine in working order	77 tons 2 cwt
Total weight of engine and tender in working order	122 tons 17 cwt
Tractive force at 75 per cent of working pressure	15,540 lb

Fig. 2—North Eastern locomotive's weight distribution diagram (superheater and non-superheater locomotives)

surfaces were modified ; in the former case on account of the inclusion of twenty-four sets of superheater elements and in the latter due to a re-arrangement of the tubes, which were reduced in number from 268 to 254.

Tenders of a new and enlarged design were introduced for these locomotives. They were of the six-wheeled type common on British railways, but were outstanding on account of their high tank capacity, amounting to 4125 gallons of water, and for the coal space, sufficient for 5 tons. In working trim the weight was 45·75 tons, making with 76·7 tons for the engine (non-superheater) a total locomotive weight of 122·45 tons.

The superheater-fitted engines had a weight of 77·1 tons, giving with the same tenders a locomotive weight of 122·85 tons in working order. The weights given comply with the makers' records as detailed on the diagram (Fig. 2). Further particulars of the leading dimensions of these engines as first built were furnished for this article by the North British Locomotive Company (to whom the writer is also indebted for the photograph reproduced) as tabulated in Table I.

TABLE I—*N.E.R. Three-Cylinder 4–4–2 Type Locomotives*

Superheater	
Cylinders three, diameter and stroke, in.	16½ by 26
Valves, piston, diameter, in	7½
Driving wheels, diameter, in	82
Boiler, working steam pressure, lb per square inch	160
Heating surfaces, square feet :	
Tubes and flues	1799
Firebox	180
Total, evaporative	1979
Superheater	530
Combined	2509
Grate area, square feet	27
Rated tractive force, lb	17,607
Non-Superheater	
Cylinders, three, diameter and stroke, in.	15½ by 26
Valves, piston, diameter, in	7½
Driving wheels, diameter, in	82
Boiler, working steam pressure, lb per square inch	175
Heating surfaces, square feet :	
Tubes	2160
Firebox	180
Total evaporative	2340
Grate area, square feet	27
Rated tractive force, lb	17,475

The engines built later at the Darlington North Road Works, while not differing materially from the original design, had slightly modified boilers, which resulted in some changes in the heating surfaces and in the weight distribution. The particulars given in Table II relate to these engines. The following short tabulation provides further particulars of a subsequent modification in the heating surfaces due to a reduction in the number of tubes, and in this connection it may be said that the change was also made to some of the boilers used for the two-cylinder "Atlantic" type locomotives.

Both the three-cylinder and two-cylinder locomotives employed in the comparative tests carried out by Sir Nigel Gresley described in his paper entitled "The Three-Cylinder High Pressure Locomotives," read

TABLE II—*N.E.R. Three-Cylinder 4–4–2 Type Locomotives*

Cylinders, three, diameter and stroke, in.	16½ by 26
Driving wheels, diameter, in	82
Boiler, working steam pressure, lb per square inch	175
Heating surfaces, square feet :	
Tubes and flues	1672
Firebox	185
Total evaporative	1857·5
Superheater	437·0
Combined	2294·5
Grate area, square feet	26·63
Rated tractive force, lb	19,300
Weights, tons :	
On coupled wheels	40·85
Engine total	79·25
Tender	46·60
Total locomotive	125·85

Some of the engines were fitted with superheaters having elements of smaller diameter giving a surface of 392 square feet and making a combined total of 2249·5 square feet.

Boiler Heating Surfaces (Modified)

Tubes reduced in number from 134 to 90	
Tubes and flues, square feet	1298·4
Firebox, square feet	185·0
Evaporative total, square feet	1483·4
Superheater, square feet	392·0
Combined, square feet	1875·4

at the Newcastle-on-Tyne meeting of the Institution of Mechanical Engineers, 1925, had these modified boilers. The paper included comprehensive particulars of the performance of these boilers, and the accompanying graph (Fig. 3), prepared from the experimental data, shows the evaporative performance obtained at firing rates attained during these trials extending between seventy-one and 103 pounds of coal per square foot of grate area per hour, corresponding to totals of 1918 and 2803 pounds per hour. The full lines in the graph cover the range of

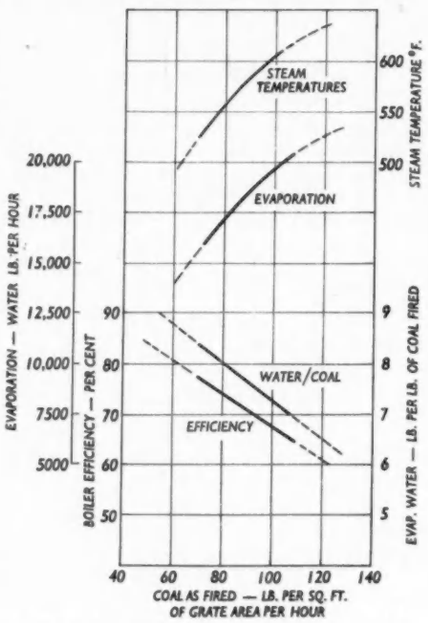


Fig. 3—North Eastern locomotive's boiler performance

the tests and the broken lines have been sketched in to indicate the probable trend of the performance of this boiler beyond the actual maximum evaporation of 19,935 lb. of water per hour, which, it appears, could have been substantially increased. The maximum evaporation of 19,935 lb. is equal to an evaporative rate of 13·4 lb. of water per square foot of evaporative heating surface per hour. The line indicating the thermal efficiency of the boiler is based on an assumed calorific value of 14,000 Th.U. per lb. of coal "as fired." These Raven three-cylinder locomotives successfully worked the principal main line express passenger services for many years.

LONDON AND NORTH WESTERN RAILWAY

C. J. Bowen Cooke's 4–6–0 Engines

For working heavy main line passenger traffic C. J. Bowen Cooke, prompted by the success attained by the superheated 4–4–0 type engine "George the Fifth," built in 1910, took the obvious course by building a superheated version of his predecessor's six-coupled engines of the "Experiment" Class, first introduced in 1905. The new design differed but little from the original, the chief difference being modifying the boiler by fitting a twenty-four element Schmidt flue tube superheater and redesigning the cylinders to include piston valves operated through the medium of rocking levers by the standard Joy's valve gear as applied to the earlier locomotives. The new cylinders were increased in diameter to 20½in in place of 19in, and, as the standard working steam pressure of 175 lb per square inch was retained, the rated tractive force was proportionately increased from 18,600 to 21,700 lb.

A noticeable difference in the appearance of the new design was the rather longer smokebox required on account of the superheater header (Fig. 4) ; otherwise, the new express did not differ from the "Experiment" Class and in all important details followed Crewe practice at that period, and, as these features have previously been referred to in former articles of this series, need not be further described. When discussing the new six-coupled locomotives introduced during 1911 on the Great Eastern Railway, a comparison of the leading dimensions will show a marked similarity between these two designs. The "Prince of Wales" Class proved in many respects successful engines in heavy passenger services, which they worked for many years until eventually superseded by the much larger four-cylinder "Sir Gilbert Claughton" Class, first built at the

TABLE III—*L.N.W.R. "Prince of Wales" Class*

Cylinders, diameter and stroke, in	20½ by 26
Driving wheels, diameter, in	75
Boiler :	
Working steam pressure, lb per square inch	175
Heating surfaces, square feet :	
Tubes and flues	1439·59
Firebox	133·33
Evaporative total	1572·92
Superheater	324·58
Combined	1897·50
Grate area, square feet	25·0
Weight, tons :	
On driving wheels	46·75
Engine total	66·5
Engine and tender	105·5
Rated tractive force, lb	21,700

Boiler steam pressure later raised to 180 lb per square inch. The tractive effort given corresponds to the original boiler steam pressure of 175 lb per square inch.

Crewe Works in 1913. Table III sets out the principal dimensions of the "Prince of Wales" Class locomotives.

GREAT EASTERN RAILWAY

4–6–0 Type Passenger Engines

S. D. Holden's six-coupled locomotives (Fig. 5) built at Stratford for express passenger services on the Great Eastern Railway represented a complete departure from existing practice on that railway, which had hitherto relied on four-coupled engines of the 4–4–0 type, known as the "Claud Hamilton" Class, designed by James Holden and first introduced in 1900, which very

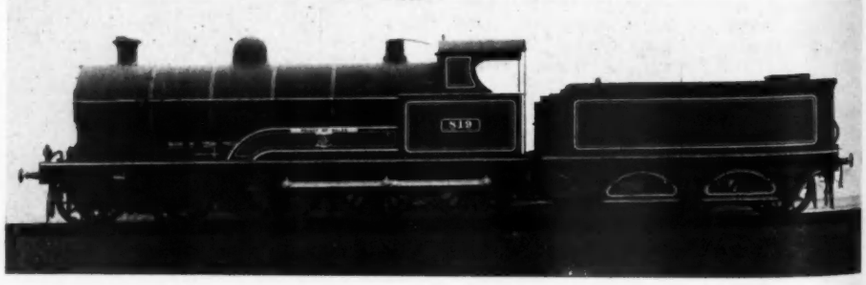


Fig. 4—C. J. Bowen Cooke's 4–6–0 type express locomotive "Prince of Wales," L.N.W.R.

successfully handled the more important services for many years. Heavier trains, however, required a more powerful type of locomotive with a higher tractive effort than could be obtained with four coupled wheels, thus making a six-coupled design necessary. Owing, however, to severe weight restrictions, exceptional care had to be exercised in preparing the design, which resulted in a comparatively light engine in relation to the power available.

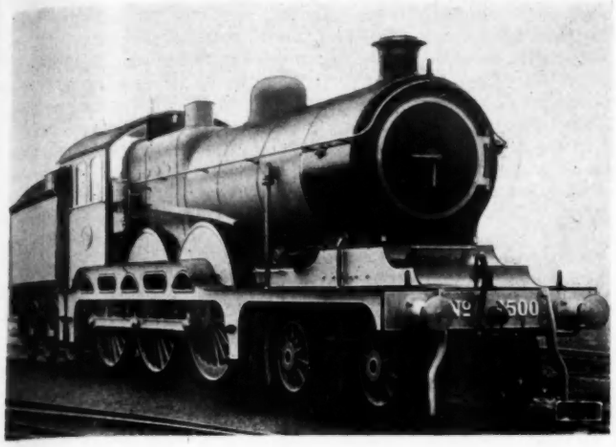


Fig. 5—S. D. Holden's 4–6–0 type express locomotive No. 1500, Great Eastern Railway

Weight conditions limited the load carried by the six-coupled to only 44 tons, which with 78in coupled wheels and cylinders 20in diameter with the long stroke of 28in, together with a working steam pressure of 180 lb per square inch, produced a rated tractive effort of 21,969 lb, comparing with 17,190 lb for the "Claud Hamilton" Class, thus representing a gain of 27 per cent, while the engine weight of 64 tons as against 50·4 tons for the 4–4–0 engines showed an increase of 28 per cent, so that the two designs were remarkably alike in their tractive effort weight ratios. A notable feature of the new engines was the adoption of two cylinders of large dimensions between the frames driving the leading pair of coupled wheels, and, as the first five engines built during S. D. Holden's term of office as Locomotive Superintendent had their coupling rod crank pins in the conventional position of 180 deg. to the corresponding inside crank pins, very high pressures were imposed on the main driving axleboxes and their guides. Later engines forming the majority of this class turned out after A. J. Hill's appointment as Locomotive Superintendent were modified by altering the position of the coupling rod crank pins. Instead of being placed at 180 deg. to their adjacent inside cranks as in conventional practice, they were placed with their crank pins coincident with the inside cranks : thereby the total load on the horn guides become the difference between the connecting and coupling rod thrusts instead of their sum, as is the case with the normal arrangement. The reactions taking place between axleboxes and their guides and the effect of wear on axlebox maintenance were fully discussed by E. S. Cox in a paper presented to the Institution of Locomotive Engineers in 1944. Referring to the modified method of arranging the inside and outside crank pins in the case of engines having large "inside" cylinders, diagrams of the loadings proposed on axleboxes with the conventional and modified crank pin spacings indicated clearly the lower loadings imposed on axleboxes and their attendant guides with the modified plan, which, however, also has features which are to some extent objectionable, summarised in the paper as follows.

1. More revolving balance is required in the wheels, since, with the ordinary arrangement, the big end and part of the connecting rod partially balance the weight of the side rods. This increase may be 800 lb on a large 0–6–0 engine, and takes the form of unsprung weight.

2. The bending moment in the crank axle is increased, and the stress in tons per square inch may increase accordingly by as much as 50 per cent.

3. The inequality in loading between the boxes on the two sides of the engine is increased. It is, of course, true that heavier balance weights are required on the driving wheel centres ; it is, however, important to note that this extra weight, being added to compensate revolving parts only, has no effect on rail impact loading caused by overbalance required to take care of the reciprocating parts. Further, with cylinders between the frames the amount of counter balance required for any given proportion of the reciprocating parts is quite considerably less than would be necessary with a pair of outside cylinders.

Perhaps it may be of interest to recall that W. Stroudley adopted this system of balancing for all his engines on the London, Brighton and South Coast Railway, though piston loadings then were relatively light. The Great Eastern engines, many of which are probably still running, have been very successful, so much so that some years ago they were rebuilt by Sir N. Gresley with larger boilers, thus prolonging their useful life in main line traffic.

Referring briefly to other points in the design of these engines, the cylinders were spaced at 22in centres, allowing main journal bearings 8½in diameter by 8½in. They had 10in piston valves placed above, operated by Stephenson's valve gear through the medium of rocking levers. The piston rods had underhung crossheads working on substantial single slide bars and were extended to pass through the front covers of the cylinders. Drawings of the cylinders and a general arrangement of the motion formed a supplement to THE ENGINEER of June 14, 1912.

The boilers represented an innovation in Stratford practice by being of the Belpaire pattern, and were larger than any hitherto constructed, with the single exception of that built for the Holden experimental ten-coupled three-cylinder locomotive of 1902. The total heating surface amounted to 1919 square feet, including 286·4 square feet contributed by the 21 element superheater. The leading dimensions of these engines given in the Table IV apply to those first built. Later engines varied slightly. The first engine, No. 1500, is illustrated by the photograph reproduced, from which it will be observed that the balance weights in the main driving wheels were in the normal position with respect to the coupling rod crank pins.

TABLE IV—*G.E.R. 4–6–0 Express Locomotives, 1500 Class*

Cylinders, diameter and stroke, in	20 by 28
Driving wheels, diameter, in	78
Boiler :	
Working steam pressure, lb per square inch	180
Heating surfaces, square feet :	
Tubes and flues	1489·1
Firebox	143·5
Evaporative total	1632·6
Superheater	286·4
Combined	1919·0
Grate area, square feet	26·5
Weight, tons :	
On driving wheels	44·0
Engine, total	66·0
Engine and tender	103·3
Rated traction force	21,969

MIDLAND RAILWAY

FOWLER'S SIX-COUPLED GOODS ENGINES

The six-coupled 0–6–0 type engines (Fig. 6) designed by Henry, later Sir Henry, Fowler and first built at Derby for general freight services on the Midland Railway in 1911 have never received the notice they deserve. They were, in fact, the last of the type to be designed at Derby, and, though not at first built in any number, they ultimately became the standard type and design for the London, Midland and Scottish Railway. Moreover, as a whole, the design was directly derived from a class of similar locomotives, introduced

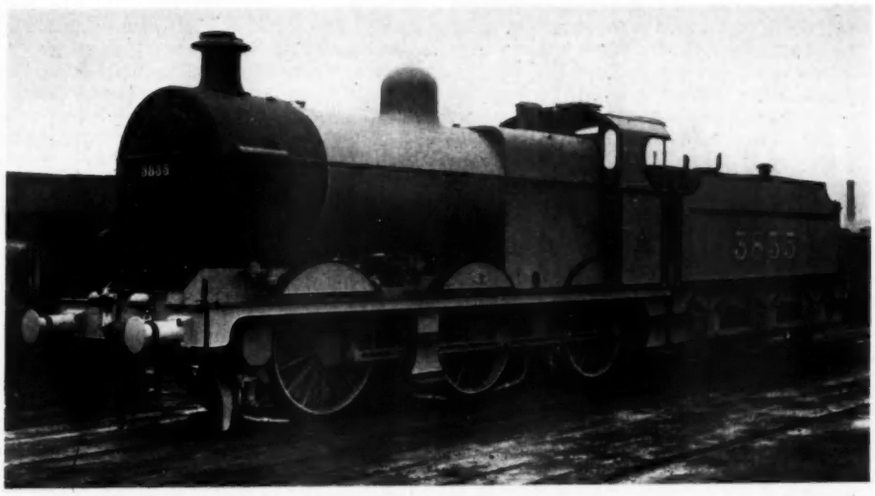


Fig. 6—Fowler's goods engines 0–6–0 type, Midland Railway

for working fast freight services on the Midland Railway by S. W. Johnson at Derby and built by Dubs and Company, Glasgow, as far back as 1878, which, in general, were typical of those built previously of the same type from Johnson's designs from which they were principally distinguished by having coupled wheels of the unusual diameter of 62½in, compared with 58in previously for engines of this type used on the Midland Railway.

Thus, these earlier locomotives initiated a wheel diameter that has remained a standard with but minor variations up to the introduction of Fowler's engines of 1911, which have 63in coupled wheels and can, therefore, be said to be a development of their predecessors of 1878. Further, it is of interest to note that the locomotives of 1878 were specially built for fast freight traffic inaugurated over eighty years ago.

The Fowler engines when built were about the largest of the type, and in certain respects what may be termed a bold design with large inside cylinders, 20in diameter, and a stroke of 26in, a steam pressure of 160 lb per square inch, which with 63in coupled wheels provided a maximum tractive force of 24,535 lb. Steam distribution was by means of piston valves giving inside admission, placed above the cylinders and actuated by Stephenson's valve gear through rocking levers. The earlier engines were fitted with a steam-operated reversing gear, according to drawings published in THE ENGINEER of December 29, 1911. The boilers, of the Belpaire pattern, had flue tube Schmidt superheaters of twenty-one sets of elements and a combined heating surface of 1483 square feet. There was a special control valve for the steam to the cylinder operating the superheater dampers in the smokebox and an automatic " by-pass " arrangement fitted to the cylinders.

These fittings, the subject of patents granted to H. Fowler and J. E. Anderson, were fully described and illustrated in THE ENGINEER. The damper control valve was designed to allow the dampers to be opened or closed according to whether the regulator was open and steam on, or closed when steam to the engine cylinders was shut off and the engine either stationary or coasting with steam shut off. Alternatively, the dampers could be held open independently of the position of the regulator, but closed if, under those conditions, the blower was put into action. The idea of this arrangement was that, when working trains making frequent stops, some loss of superheat would occur if the dampers were closed whenever steam was shut off, and that with stops of short duration the superheater element would not become overheated even though no steam was flowing through it. When, however, the control valve was set to hold the dampers open and the blower put into action, the valve automatically shut off the steam supply to the damper operating cylinder, thus closing the dampers and so preventing any overheating of the superheater elements.

The cylinder by-pass arrangement was in fact based on Schmidt's general idea but improved, for, whereas the Schmidt arrangement was hand-operated, the Fowler-Anderson apparatus was automatically controlled. This arrangement consisted of a pipe connection between each end of the cylinder, fitted midway in the length with a single seated valve actuated by a piston working in a cylindrical chamber attached to that containing the valve. With steam on, i.e. the regulator opened, the piston closed the valve, so cutting off connection between each end of the cylinder ; on the other hand, with the regulator shut, the piston automatically opened the valve, so establishing a connection between each end of the cylinder, and thus providing an effective by-pass and a free running engine when coasting. This by-pass device was a feature of Derby designs for many years up to and including the " Royal Scot " locomotive of 1927. It has, however, of late ceased to be fitted, an obvious objection to its use being an increase in cylinder clearance volume.

When first introduced, the new large 0–6–0 engines under notice were not built in quantity, as was the case later when, with slight modifications, they became the standard 0–6–0 freight locomotives of the London, Midland and Scottish Railway. As a class, they have without doubt been most useful engines even though, due to the high piston loads and the inside position of the cylinders, the main driving axleboxes are reported to have required rather much attention. Here it may, however, be noted that possible difficulties of this nature were foreseen when the design was prepared, by making the main driving axle journals 8½in diameter by 8½in, comparing with 8in by 8½in for the leading and trailing axles. It may in this connection be recalled that axlebox bearing pressures, investigated by E. S. Cox in his paper previously mentioned, referred to these particular locomotives.

TABLE V—*Midland Railway*
Principal Dimensions of 0–6–0 Engines

	As first built	As standard
Cylinders :		
Diameter and stroke, in...	20 by 26	20 by 26
Wheels coupled, diameter, in	63	63
Boiler :		
Working steam pressure, lb per square inch...	160	175
Heating surfaces, square feet :		
Tubes and flues	1045	1034
Firebox	125	124
Evaporative	1120	1158
Superheater	313	246
Combined...	1483	1404
Grate area	21·1	21·1
Weight, tons :		
On coupled wheels	49·1	48·75
Engine, total	49·1	48·75
Engine and tender	88·2	89·95
Rated tractive force, lb	22,410	24,555

Table V gives particulars of the dimensions of these engines as first built and as later built as a L.M.S. Standard class.

GREAT WESTERN RAILWAY

CHURCHWARD'S 2–6–0 TYPE ENGINES

The 2–6–0 type locomotives designed by G. J. Churchward for mixed traffic on the Great Western Railway, though not the first with this wheel arrangement to be built either for the Great Western or other British railways, nevertheless undoubtedly proved to be the forerunners of others of the same type on other railways, notably the Great Northern and also the South Eastern and Chatham Railway.

As a type, the design dates back to 1878 when it was introduced on the Great Eastern, for which line William Adams prepared a design just before leaving Stratford to assume the position of Locomotive Superintendent of the London and South Western Railway at Nine Elms. The engines were actually built after J. Massey Bromley's appointment as successor to Adams. Intended for main line freight traffic and to provide more powerful locomotives than the existing 0-6-0 type engines then in service, they were, however, not particularly successful and nothing more was done with engines of the 2–6–0 type until, in 1900, a number were supplied by the American Locomotive Company and the Baldwin Locomotive Works for freight services on the Great Northern, Great Central and Midland railways. Particulars with illustrations of these engines will be found in THE ENGINEER of December 29, 1950.

In the same year W. Dean designed at Swindon some examples of the type for heavy freight traffic on the Great Western. These consisted of two different classes, one of which, known as the " Aberdares," was very successful, numbering in all eighty locomotives. No further engines of this type were built till those now particularly under notice were designed for working freight or passenger traffic in 1911. The design was largely prompted by the extensive use of 2–6–0 type engines on North American railways where they were much in evidence at that time in general services, handling either freight or passenger traffic as required. The Swindon engines as first built are illustrated by Fig. 7. In all respects the standard practice was strictly followed, resulting in a successful and versatile engine which, when examined in detail, is of considerable interest as bringing out certain features consequent on strict adherence to standard practice.

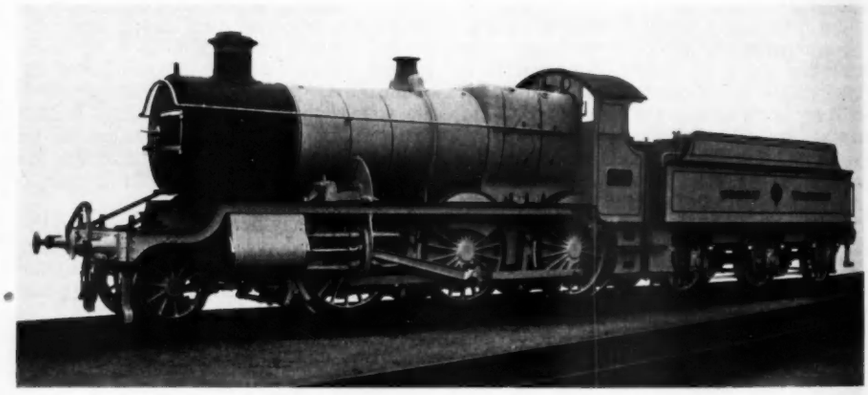


Fig. 7—G. J. Churchward's mixed traffic 2-6-0 type, Great Western Railway.

One of these points brought to notice is the question of balancing the reciprocating parts of the motion. There are certain well-defined reasons for this ; they are, in the first place, the comparatively light weight of the engine of 62 tons without the tender, the wide pitch of the cylinder centres, which appears to be 6ft 11in, and the long piston stroke of 30in, constituting features tending to aggravate the balancing problem. With this in mind, the writer has, through the courtesy of the C.M.E., Western Region, British Railways, obtained particulars of the weight of the reciprocating parts of the motion, which is 759·95 lb per cylinder, and the proportion balanced seems, as might be expected, to have been the subject of experiments ; thus,

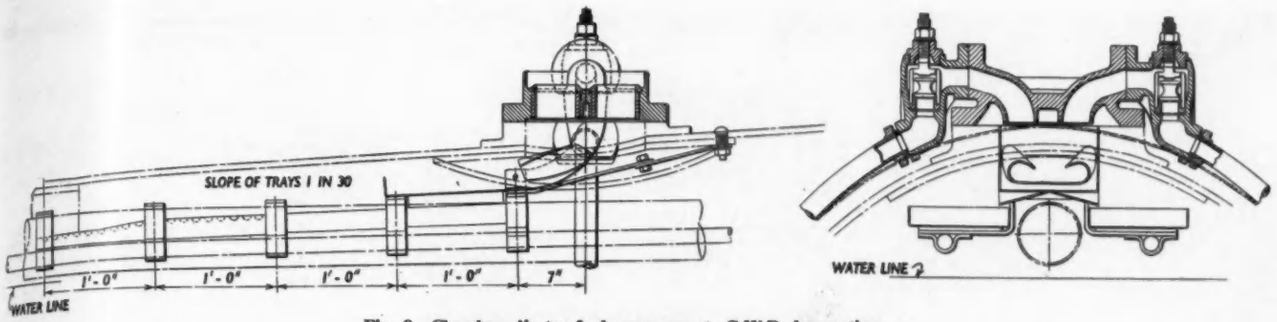


Fig. 8—Churchward's top-feed arrangement, G.W.R. locomotives

in the first engines built, Nos. 4301–4320, the proportion balanced was 82 per cent, reduced in the case of those later built to either 75 or 70 per cent.

Before giving further consideration to these engines so far as the counterbalancing of the reciprocating parts is concerned, it will be useful and, in fact, desirable to refer to a paper on "Balancing Locomotive Reciprocating Parts" by E. S Cox, Institution of Mechanical Engineers, 1941, giving some information concerning a class of 2–6–2 type passenger tank engines built for the Great Western in the first place in 1929.

Particulars of the reciprocating weights per cylinder were given, also the estimated dynamic rail impact loadings per coupled wheel at speed in revolutions per second of 5 and 8 seconds respectively, corresponding to speeds of 61 and 97 m.p.h. It is stated that the reciprocating parts per cylinder amount to 731 lb and that 66·6 per cent is balanced, giving rail impact loading equally divided over each of the three wheels on each side of the engine of 3·35 tons.

It is also stated that in some cases it has been found desirable to balance as much as 85 per cent of the reciprocating parts, thereby reducing the inertia effects of the unbalanced parts, which were found to be excessive when a less proportion was balanced. The variations in the drawbar tractive effort were sufficient to disturb passengers under certain conditions of speed. It is important to note that, so far as they influenced balancing problems, these 2–6–2 tank engines and the 2–6–0 tender engines are in design exactly alike. In fact, the 2–6–0 design, so far as the engine is concerned, is only the tank design without the side tanks and rear coal bunker with the main frames suitably reduced in length. Further, some of these 2–6–2 tank engines had the standard No. 4 boiler as used for the new 2–6–0 class.

It may here be observed that all these standard engines had cylinders of identical design, differing only with respect to the diameters, which varied from 18in to 19in. There were differences in the heights of the saddle positions to suit different boilers. The maximum width of 8ft 11in over the cylinders is the same for all the classes that have 30in stroke cylinders and, as the distance between the cylinder centres for the 19in engines of the 2-8-0 Class 4700 is 6ft 11½in, it seems safe to assume this is a standard dimension. For the sake of clarity, Table VI is presented, setting out a brief analysis of the balancing conditions for the 2–6–2 tanks and the 2–6–0 engines.

On the assumption, therefore, that the cylinders are of the same design for the 2–6–2 and 2–6–0 engines and that the speeds in revolutions per minute are as for the 2–6–2 tank engines producing balancing conditions as set out in column 2, the dynamic rail loadings will in all cases be proportional to the respective weignt actually balanced, based on the resulting values given in column 2, which are taken from the paper previously mentioned.

With respect to the magnitude of the inertia forces set up by the unbalanced reciprocating parts, these have not been estimated ; only the relation between these weights and the total locomotive weights is shown to indicate what this ratio may oe to obtain satisfactory conditions as regards variations in the tractive effort exerted on the train of vehicles. So far as the general design and construction are concerned, these locomotives were strictly in accordance with standard practice at that period. In fact, as already stated, the engines were simply a modification of the standard 2–6–2 tank engines of the class which were fitted with the Swindon No. 4 boiler.

Eventually a considerable number of these 2–6–0 engines were put into traffic, and are understood to have been very successful. The leading dimensions of the class are given in Table VII, which also includes similar particulars of an American design of the same type and of similar tractive effort. These engines were built for the Boston and Maine Railroad by the Manchester Locomotive Works, Manchester, N.H., in 1900. They were not fitted with superheaters, which at that time were not available for locomotives.

Churchward's "Top Feed" Arrangement

A distinctive feature of Great Western locomotives is seen in the feed water pipes connecting with the top feed fittings attached to the safety valve mounting, clearly shown by the photograph of the 2–6–0 type locomotive.

Through the courtesy of the present C.M.E., R. A. Smeddle, the writer is able to illustrate this equipment in its latest form as applied to Great Western locomotives (Fig. 8). The adoption of this system of supplying the boiler feed water through the steam space was, it may be of interest to recall, due to a suggestion made by a past editor of The Engineer, Vaughan Pendred, when contributing to the discussion following the reading of Churchward's classic paper, "Large Locomotive Boilers," Institution of Mechanical Engineers, 1906. The arrangement is so well shown by the drawing that little explanation is required. It differs but little from that in use for many years past, originally developed as a result of trials made with other similar designs involving the fitting of trays in various forms for distributing incoming feed water in the boiler. It will be observed that the two non-return valves are neatly mounted on the base of the safety valve fitting, which, in turn, serves as a cover for an entrance into the boiler when required, and also provides access to the feed equipment for inspection and cleaning. This method of supplying boiler feed water is credibly stated to have given entire satisfaction and has in fact been introduced on a large scale during recent years on the L.M.S. Railway and for the standard types of steam locomotives designed under the direction of R. A. Riddles when responsible as the Member of the Executive for Mechanical and Electrical Engineering. The drawing showing this feed water equipment is considered to be a valuable contribution to the records of Swindon locomotive developments so far referred to in these articles reminiscent of practice half a century ago.

Table VI—*G.W.R. Locomotives. Balancing Reciprocating Parts Constant Speed 300 r.p.m.*

Locomotive type	2-6-2		2-6-0	
Locomotive weight, lb	175,280		228,480	
	1	2	3	4
Reciprocating parts :				
Weight per cylinder, lb	731	731	759·95	759·95
Percentage balanced	85	66·6	82	70
Over balance, lb	620·3	486·8	623·1	531·9
Under balance, lb	110·7	244·2	136·8	228·0
Under balance/locomotive weight ratio	1 : 587	1 : 720	1 : 1671	1 : 1000
Average weight tons, per coupled wheel	8·73	8·73	8·76	8·76
Hammer blow average per wheel, tons	4·25	3·35	4·28	3·65
Hammer blow, per cent of static load per wheel	48·6	38·3	48·8	41·6

Table VII—*Principal Dimensions 2–6–0 Locomotives : Great Western and Boston and Maine Railways*

Railway	G.W.R.	B. & M.R.
Date	1911	1900
Cylinders, diameter and stroke, in	18½ by 30	19 by 26
Coupled wheels, diameter, in	68	63
Steam pressure, lb per square inch	200	200
Heating surfaces, square feet :		
Tubes and flues	1349·64	—
Firebox	128·72	—
Evaporative total	1478·36	1892
Superheater	191·79	—
Combined	1669·65	—
Grate area, square feet	20·56	30·3
Weight, tons :		
On driving wheels	52·6	56·7
Engine, total	62·0	64·2
Engine and tender	102·0	113·1
Rated tractive force, lb	25,670	25,300
Factor of adhesion	4·36	5·12

LANCASHIRE AND YORKSHIRE RAILWAY

G. Hughes' Superheater Tank Engines

Following the application of the Schmidt superheater, in the first instance, to 0–6–0 type freight engines in 1906 and to passenger engines of the 4–4–0 type two years later, in 1908, the same plan was followed in 1911, when a new series of 2–4–2 type tank engines for passenger services were designed and built at Horwich by G. Hughes. These engines, one of which is illustrated in Fig. 9, were in general design like those of the same type originally built at Horwich to the design of J. A. F., later Sir John, Aspinall in 1889. They were possibly the best known engines of the type, as well as being the largest and most powerful, and were excellent engines. For a

Fig. 9—L. and Y. passenger tank locomotive 2–4–2 type, superheated. G. Hughes, 1911

long period of years they successfully worked the major part of the passenger services on one of the busiest and possibly the most difficult railways in England. The leading dimensions are given in Table VIII, which includes also the same information for the superheated series designed by G. Hughes in 1911.

The Aspinall locomotives followed general Horwich practice, strictly standardised in many respects; thus, they had inside cylinders, 18in by 26in, Joy's valve gear and comparatively large boiler eventually used for Aspinall's 4–4–0 and 0–6–0 passenger and freight standard engines. As stated, the dimensions given apply to the earlier examples of these excellent engines; those later built were rather larger, having a larger coal bunker and somewhat greater tank capacity. As first built, they weighed 59·15 tons in working order. The superheated version was similar to the later enlarged series of the original engines, though in certain respects they present marked differences. The boilers, for instance, were of the Belpaire pattern, but of generally same overall dimensions. The working steam pressure was increased to 180 lb per square inch, which, in conjunction with the larger cylinders, 20½in by 26in, and the standard 68in wheels, increased the rated tractive force to the high figure of 24,649 lb.

A circular smokebox resting on a cast iron saddle was another prominent modification, as was also the arrangement of valve gear with respect to the method of connecting with the piston valves. The valves were above the cylinders, but placed slightly towards the outside, next the main frames. The Joy's gear was applied as standard, but in place of a valve spindle a short spindle fitted with a plunger form of guide working in a cylindrical fitting attached to a cylinder casting. This spindle made connection with a rocking lever working in the horizontal plane and at its outer end connected with the valve spindle. Like the original locomotives, the leading and trailing wheels were mounted on axles having radial journal box similar to the Webb pattern as used on the L.N.W.R. and a water scoop capable of scooping water from the troughs when the engine is travelling in either direction. At various times the writer has travelled behind these engines of the older and later designs, and has always considered them most capable engines which were doubtlessly a valuable addition to the locomotive stock of the railway.

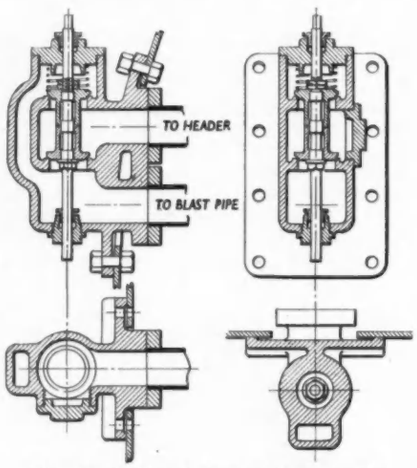


Fig. 11—Robinson's header discharge valve

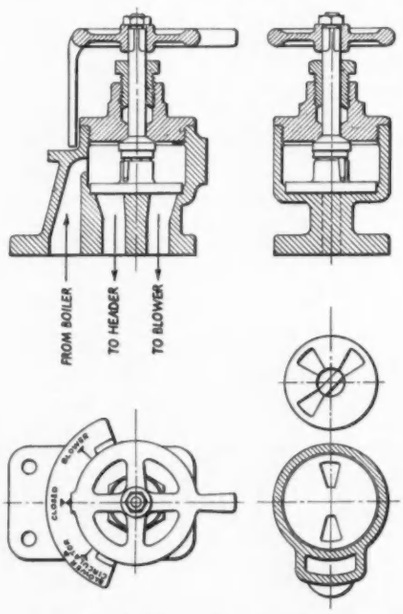


Fig. 10—G.C.R.–J. G. Robinson's combined blower and circulating valve

TABLE VIII—*Lancashire and Yorkshire Railway 2–4–2 Tank Engines*

	1889	1911
Cylinders, diameter and stroke, in	18 by 26	20½ by 26
Coupled wheels, diameter, in	68	68
Steam pressure, lb per square inch	160	180
Heating surfaces, square feet :		
Tubes	1108·7	—
Firebox	107·7	—
Evaporative	1216·4	897
Superheater	—	195
Combined	—	1092
Grate area, square feet	18·75	18·75
Weight, tons :		
On coupled wheels	31·65	39·25
Locomotive total	55·95	66·45
Rated tractive force, lb	16,432	24,649

GREAT CENTRAL RAILWAY

Locomotives designed by J. G. Robinson and built at the Gorton Works of the Great Central Railway comprised a 2–8–0 locomotive for heavy freight traffic and a large tank engine of the 4–6–2 type for local passenger services in the London district; of these, the 2–8–0 engines were possibly the better known on account of the fact that they were adopted by the War Office for services overseas during the 1914–18 war, when very large numbers were supplied by a number of firms to drawings and specifications furnished by the railway company.

THE ROBINSON SUPERHEATER

Before, however, dealing specifically with these two locomotive designs, some attention should be given to the development of the flue superheater, as used for these locomotives. This development, due to J. G. Robinson, which became widely known as the Robinson superheater, while being in principle like the Schmidt flue tube arrangement previously referred to in these articles, differed in the method used for fixing the superheater pipes to the header, placed as usual in the top of the smokebox. Whereas in the Schmidt type these pipes were jointed to the header by a system of bolts and clamps, Robinson simply expanded the pipes in the header casting in the same way boiler tubes are held in the firebox and smokebox tube plates.

This was actually the special feature of the Robinson superheater; fixing the tubes, or elements, as they were usually called, in this manner, required a special form of tube expander and also required the provision of a number of removable covers in the front wall of the header casting to give access to the inside for the expanding operation and also for removing the tubes when required. Here it may be mentioned that in practice it was found to be perfectly possible to withdraw the tubes with special tools devised for the purpose and re-insert them again as might be desired. This superheater became extensively used on many railways in different countries. With the superheater, Robinson also brought out various ancillary

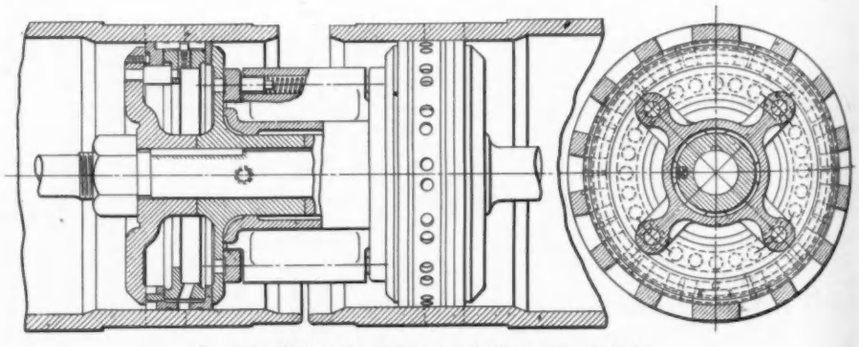


Fig. 12—Robinson's piston valve, inside steam admission

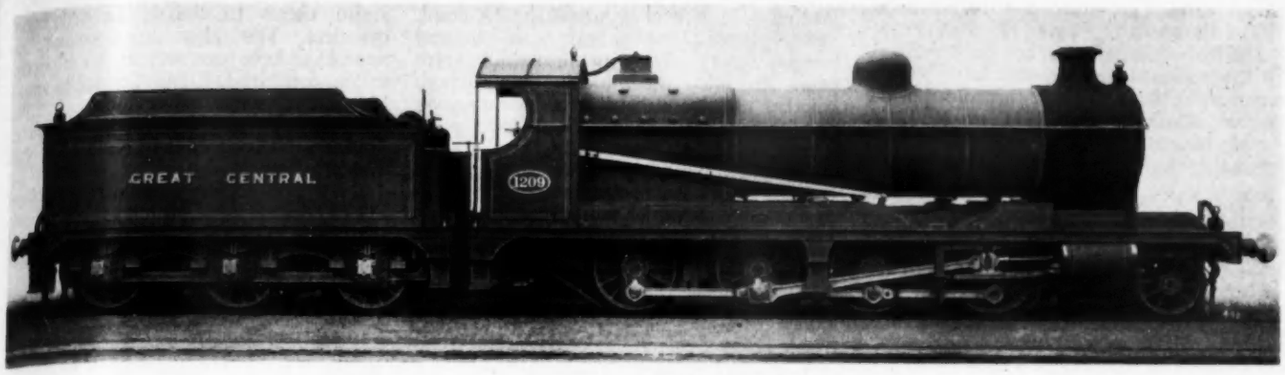


Fig. 13—G.C.R.–J. G. Robinson's heavy freight locomotive, 2–8–0 type

fittings, which should also be mentioned. In the first place, dampers to cut off the air flow through the large tubes containing the elements used only in the earlier stages of the development of this superheater, as was also an arrangement of what was called "draught retarder," which consisted of a series of steam jets fitted in the smokebox opposite and concentric with each of the large tubes containing the superheater elements, the idea being that, when the regulator was closed and steam, therefore, shut off, the steam jets could be started, thereby counteracting the draught in the large tubes, so preventing the elements from becoming overheated.

This arrangement necessitated the fitting of a considerable amount of piping in the smokebox, and was not favoured for this reason, and to what extent it was used the writer does not recollect. Improved equipment was later introduced and is shown by the accompanying drawings showing the fittings employed. One of these is described as a combined blower and circulating valve. The valve (Fig. 10), mounted on the boiler in the cab, had three positions : (1) Steam shut off ; (2) Blower only in action ; and (3) Blower and circulating steam in action. Position (3), therefore, allowed steam to circulate through the superheater when the blower was in use, so preventing the induced draught set up from overheating the elements. Complementary to this blower valve, a header discharge valve was fitted, as shown by the further drawing (Fig. 11). This valve, fixed on the side of the smokebox, was actuated by the regulator control in the cab. With the regulator closed and steam off, the discharge valve was opened and any steam from whatever cause in the superheater escaped from the valve to the blast pipe, as indicated by the drawing. It will, therefore, be seen that, if for any reason the blower was required when the locomotive was stationary, the steam circulating through the superheater elements would escape through the blast pipe after passing through the superheater.

Robinson Piston Valves

Additional to the special fittings described, a piston valve was also brought out, patenting a device for automatically releasing any undue pressure arising from any cause in the cylinders. Such a valve, as arranged for inside admission, is shown by the accompanying illustration (Fig. 12), which is largely self-explanatory. It will be noted that the packing ring, of the wide pattern, had a number of holes round its periphery through which any steam in the cylinder at a higher pressure than that in the steam chest could escape if its pressure was such that it could lift the ring covering the passage ways in the valve body leading to the steam chest. The ring valve was held up against the valve by means of the springs shown and also by the admission steam pressure. The valve would, therefore, release any water trapped in the cylinder after the valve had closed the exhaust port and also prevent the compression steam from reaching too high a pressure. A similar valve, arranged for outside admission, was also designed.

The Robinson 2–8–0 Locomotives

The 2–8–0 heavy locomotives (Fig. 13) built at Gorton for the G.C.R., though notable engines, were not the first of the type to be introduced on a British railway ; this distinction belongs to Churchward's design, built at Swindon for the G.W.R. in 1903. As a type, the 2–8–0 is of American origin, due to the Baldwin Locomotive Works, Philadelphia, where it was first commercially built so long ago as 1866, though its use did not become general till some years later when it took the place of engines of the 2–6–0 type for freight traffic. The Swindon locomotives were in many respects a successful copy of American locomotive practice, and of the Gorton engines it may possibly be said they were largely a successful copy of the 2–8–0 locomotives being actively developed during the earlier years of the present century for heavy freight services on the broad gauge lines of the Indian Railways. These engines, it may be remembered, were originally built from designs formulated by the British Engineers Standards Association (B.E.S.A.) during the first decade of this century. The Engineer has on several occasions illustrated and described the locomotives built for railway services in India and, as illustrating the general similarity existing between the G.C.R. and Indian locomotives, attention may fittingly be drawn to The Engineer of July 19, 1912, where drawings of some locomotives of the 2–8–0 type for the East Indian Railway will be found. The likeness existing between these two designs will be manifest. The East Indian engines, while being generally in compliance with the approved standards, differed in respect to certain details, certain deviations from the standard specifications being allowed to suit the requirements of individual railways.

Reference may also be made to an article by J. G. H. Warren discussing certain aspects of the B.E.S.A. Standards involving a reference to the Robinson engines, published in The Engineer of December 26, 1924.

The principal features of the engines, fifty of which were built by the North British Locomotive Company Ltd. in 1912, were the large outside cylinders with inside valve chests and Stephenson's valve gear and, as will be seen from the accompanying illustration, the third pair of coupled wheels were the main driving wheels. The boiler, of the Belpaire pattern, had a twenty-two element Robinson superheater and a working steam pressure of 180 lb per square inch. Except for the provision of the superheater, the features mentioned were in common with the East Indian locomotives, which were not superheater-fitted. Table IX summarises certain dimensions of the two designs and shows the similarity existing between them.

Table IX—*Comparative Dimensions of G.C.R. and E.I.R. 2–8–0 Type Locomotives*

	G.C.R.	E.I.R.
Railway		
Gauge	4ft 8½in	5ft 6in
Cylinders, diameter and stroke, inches	21 by 26	20 by 26
Coupled wheels, diameter, inches	56	54
Boiler steam pressure, lb per square inch	180	180
Total heating surface, square feet ...	1745	1776
Grate area, square feet	26	32
Weight, tons :		
On coupled wheels	66·2	59·47
Engine	73·2	65·57
Engine and tender	121·5	—
Tractive force, lb maximum	31,326	29,275
Boiler heating surfaces :		
Tubes and flues	1349	—
Firebox	154	—
Evaporative	1503	—
Superheater	242	—
Combined...	1745	—

4–6–2 Type Tank Engines

The tank engines built in the first instance for passenger services in the London district were the second of this type to be used on British lines, the first being C. J. Bowen Cooke's locomotives for the London and

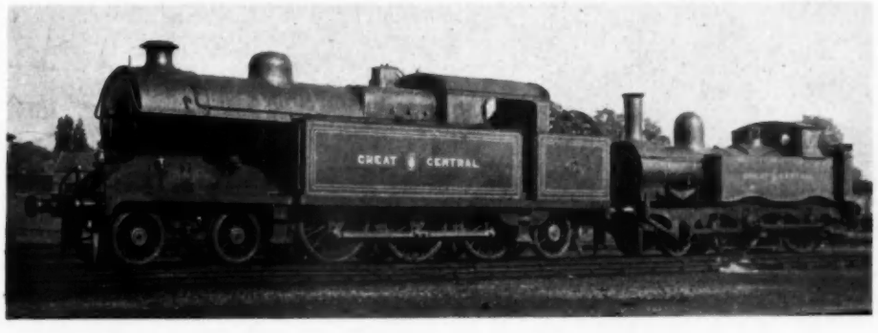


Fig. 14—G.C.R. 4–6–2 type passenger tank locomotive

North Western, introduced in 1910, illustrated in THE ENGINEER of August 12, 1960.

The Robinson design as first built is shown by the accompanying illustration (Fig. 14) representing the twenty-one turned out of the Gorton Works during 1911 to 1917. A further ten, built in 1923, differed from the original by having side window cabs.

TABLE X—*G.C.R. 4–6–2 Tank Locomotives*
Principal Dimensions

Cylinders, diameter and stroke, in	20 by 26
Driving wheels, diameter, in	67
Boiler steam pressure, lb per square inch	160
Heating surfaces, square feet	
Tubes and flues	1294
Firebox	141
Evaporative	1435
Superheater	214
Combined, square feet	1649
Grate area, square feet	21
Weight, tons, on coupled wheels	54
Engine, total	85
Tank capacity, gallons	2330
Coal bunker, tons	4

LONDON AND SOUTH WESTERN RAILWAY

DRUMMOND'S FOUR-CYLINDER EXPRESS LOCOMOTIVES

The locomotives illustrated by Fig. 15, built at Eastleigh to the designs of D. Drummond, were the last of this type and construction, and in many important respects represented a departure from previous examples of the same general type and design previously built. They were the fourth lot of four-cylinder six-coupled passenger engines introduced by Drummond and, though having many features characterising former similar locomotives already described and illustrated in previous articles of this series, there were, however, some noteworthy differences.

In the case of the three earlier four-cylinder designs, the outside cylinders were placed between the trailing wheels of the leading four-wheeled bogie and the leading pair of coupled wheels and the inside cylinders under the smokebox, thus assimilating Churchward's practice for the Great Western four-cylinder engines.

Further, whereas Drummond's previous practice was to fit four sets of valve gear using Stephenson's gear for the inside cylinders and Walschaerts for the outside pair, the latest and last examples of this type now under notice had only two sets of valve gear, Walschaerts being retained for the outside cylinders, the valves for the inside pair being operated by horizontal levers connecting the respective valve spindles for the adjacent valves for the outside and inside cylinders. As distinct from the earlier engines, the four cylinders were arranged in line transversely with their respective piston valves above arranged for outside admission. As in earlier examples of the type, the drive was divided, necessitating longer connecting rods for the outside cylinders driving the intermediate pair of coupled wheels. The leading pair of driving wheels had a crank axle of the built-up pattern with balanced cranks. Dispensing with the inside valve gears simplified these locomotives, though whether the steam distribution was so good as with four sets of independent valve gears is another matter.

Compared with the earlier engines, the coupled wheels were larger in diameter—79in as against 72in, which would possibly be an improvement for fast running. The boilers were of the same size as those used for the four-cylinder engines built in 1908 and described in THE ENGINEER of November 21, 1958, and, like them, had an arrangement, the purpose of which was to dry the steam on its way from the boiler to the cylinders. Actually, two different steam dryers seem to have been tried with these particular locomotives. One of them, similar to that previously fitted, was very well shown by some excellent drawings published in THE ENGINEER of July 21, 1911. In this arrangement, instead of fitting two steam pipes in the smokebox taking the steam from the boiler to the cylinders in the usual manner, their place was taken by a number of tubes 1½in outside diameter; there were thirty-six of these tubes taking the place of each steam pipe, thus making a total of seventy-two, providing a total surface, outside, of 175 square feet to absorb heat from the smokebox gases.

Each set of thirty-six pipes comprised three nests of twelve, fitted into a top header in the upper part of the smokebox and to a similar header in the lower part of the smokebox having branch connections with the adjacent steam chests to the inside and outside cylinders. The alternative method tried appears to have been very similar in principle to that fitted by J. E. MacConnell to some of his famous single driver locomotives built at Wolverton in 1852 for service on the Southern Division of the London and North Western Railway.

Drawings of these locomotives, published in *The Locomotive* of March 15, 1950, showed the device and are otherwise of considerable interest to anyone who may be conversant with the subsequent developments in locomotive practice at Crewe some twenty years later. MacConnell appears to have taken the steam from the boiler to the cylinders after passing it through a chamber immediately in front of the smokebox tube plate and through which there were a number of tubes, presumably registering with an equal number of boiler tubes in the tube plate. A certain amount of the hot gases would be drawn through these tubes to the dryer, which would dry the steam as it passed over the tubes on its passage through the dryer. This was MacConnell's plan and that fitted by Drummond, though its application was a little different, in principle was exactly the same. Drawings of these Drummond engines of 1911 showing this steam dryer will be found in "The Development of British Locomotive Design," E. L. Ahrons, 1914. In general, these engines followed Drummond's well-known practice; thus they had the familiar cross water tubes to the firebox and also included the Drummond feed water heating equipment, largely adopted for South Western engines of that period in its locomotive history. These engines are well shown by the excellent photograph reproduced, for which the writer is indebted to R. G. Jarvis of the Chief Mechanical Engineer's Department, Brighton Works of the Southern Region.

The leading dimensions of these engines are given in Table XI.

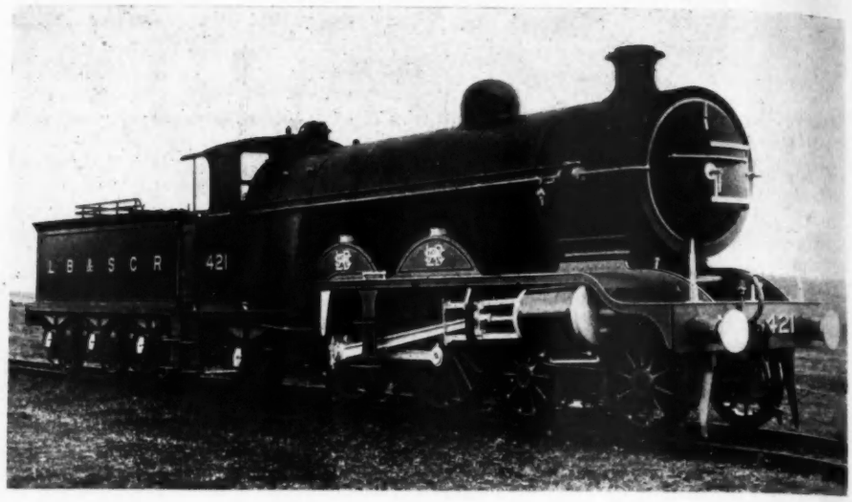


Fig. 16—L.B. and S.C.R. superheater "Atlantic" type express locomotive, D. E. Marsh

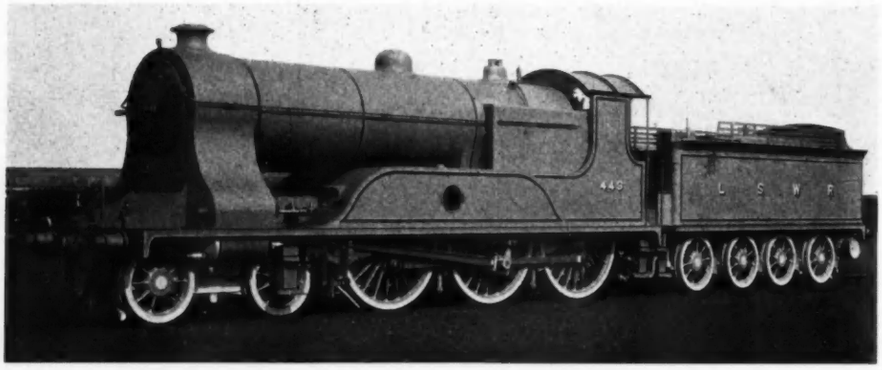


Fig. 15—L. and S.W.R.–Drummond's four-cylinder 4–6–0 type locomotive for express passenger traffic

TABLE XI—*L.S.W.R. Four-Cylinder Express Locomotives*

Cylinders, diameter and stroke, in	15 by 26
Driving wheels, diameter, in	79
Steam pressure, lb per square inch	200
Heating surfaces, square feet :	
Tubes	1580
Firebox	340
Total	1920
Grate area, square feet	31·5
Weight, tons :	
On driving wheels	54·95
Engine total	76·3
Engine and tender	122·3
Rated tractive force, lb	25,160
Firebox heating surface includes water tubes :	
Firebox, square feet	40
Water tubes, square feet	200

LONDON, BRIGHTON AND SOUTH COAST RAILWAY

"ATLANTIC" TYPE LOCOMOTIVES (SUPERHEATED)

D. E. Marsh, who had already taken an active part in the application of the Schmidt Flue Tube superheaters to locomotives, took a further step in 1911 by building at Brighton a modified series of the "Atlantic" type locomotives, which were first built in 1905, fitted with superheaters and enlarged cylinders with piston valves.

One of these new locomotives is illustrated in Fig. 16, and the leading dimensions are given in Table XII.

TABLE XII—*L.B. & S.C. Ry. "Atlantic" Locomotives*
Principal Dimensions

Cylinders, diameter and stroke, in	21 by 26
Driving wheels, diameter, in	6$\frac{1}{2}$
Boiler steam pressure, lb per square inch	170
Heating surfaces, square feet :	
Tubes and flues	1895
Firebox	136·47
Evaporative	2031·47
Superheater	460
Combined	2491·47
Grate area, square feet	3095·8
Weight, tons :	
On coupled wheels	341·75
Engine, total	68·25
Engine and tender	107·5
Rated tractive force, lb	20,906

ACKNOWLEDGMENTS

In conclusion, the writer wishes to acknowledge valuable assistance received in the preparation of this article from R. Arbuthnott, North British Locomotive Company, E. S. Cox, Assistant Chief Mechanical Engineer, British Transport Commission, London ; R. A. Smeddle, C.M.E., Western Region, B.R. ; R. G. Jarvis, C.M.E. Department, Southern Region B.R, Brighton ; T. C. B. Miller, C.M.E. Eastern Region, B.R.; R. Stephenson and Hawthorns, Ltd. and C. R. H. Simpson.

Letters to the Editor

POLLUTION OF THE TIDAL THAMES

SIR,—As in most cases of pollution, the main problem in the River Thames is the deficiency of oxygen in the water and the failure of natural re-oxidisation processes to keep pace with the requirements of oxygen arising from polluting substances. The cost of complete treatment of sewage effluents into the river would, as you say, run into many millions of pounds, but it has occurred to me that there may be an alternative.

The only source of oxygen to replenish that used in oxidising the sewage effluents, other than from nitrates and sulphates, appears to be oxygen dissolved at the surface of the river, which must obviously be inadequate, particularly where the water has an appreciable depth. I wonder whether it would be possible to have small air compressor stations at intervals along the river, the compressed air being passed to diffusers on or near the river bed.

By this means there would be a constant supply of oxygen which would be dissolved much more readily as bubbles rise to the surface than is atmospheric oxygen dissolved at the surface. The technique would be somewhat similar to that which has been used for the prevention of ice formation in lakes, harbours etc., in certain parts of the world. I am sure the cost would be very much less than the cost of treatment of some of the present effluents to an acceptable B.O.D.

The principle would be very welcome in many other of our polluted rivers, such as the Tyne, where primary settling of sewage might be a practicable proposition but secondary treatment is unlikely because of cost and lack of space.

J. H. GOLD

Whitley Bay,
November 2, 1961.

ACTIVITY IN OPERATIONAL RESEARCH

SIR,—Our attention has been drawn to the note in your issue of October 20 in which you castigate this company for pointing to the wartime achievements of Operational Research rather than quoting "actual figures" about peace-time results. It may have occurred to your readers that a consultant who published details of his clients' affairs in the Press would not retain their confidence for long. The wartime results have been published officially by the sponsors of the work.

In fact we tried to give indications of the value of civil applications of O.R. in the written material handed out at our reception—including a case in which a company's profit had been doubled. This material, which I may say was issued in the hope that you would read it, also refers *passim* to our correct name—which is Sigma, not SIGM as you say.

STAFFORD BEER

Managing Director,
Science in General Management Ltd.,
69, Grosvenor Street, London,
October 31, 1961.

[Our apologies are due for the misprint.—Ed. THE E.]

A DISCREPANCY OF INDICATION

SIR,—As the designer of the engine referred to, I have read the article by Messrs. Walker and Plumb (October 27, 1961, page 689) with some interest, and would be grateful if you could afford me space for a few observations.

This engine returned best full-load (100 lb per square inch brake mean effective pressure) fuel consumption on oil with the injection setting such that the maximum pressure was of the order of 1000 lb per square inch, and $dp/d\theta$ about 70 lb per square inch per deg. This latter figure is considerably greater than the figures obtained by the author and I can only conclude that the injection timing was insufficiently advanced. At the "design" rate of pressure change the engine noise was described as "healthy"—no violent knock, but plenty of evidence of combustion! By contrast, when running on gas, even at brake mean effective pressure of 110 lb per square inch, the engine was markedly quieter, so much so that valve-gear noise was obtrusive. The gas engine should be quieter than the oil engine and not the reverse.

I have always found that noise and rate-of-pressure rise are connected, though I would hesitate to suggest any mathematical relationship between dB and pound per square inch per deg. I cannot believe, however, that a rate of pressure rise of 294 lb per square inch per deg. could be tolerated ; at 100 lb per square inch per deg. the noise was bad enough ; at three times that figure I should be in fear of disintegration of the big-end, if not the piston. (I note a brief reference to "Mechanical failure" in the paper!)

Accepting that the figure obtained for oil operation is too low, could it not be that the figure for gas is also suspect? I think it is. My experience was that only the most stringent precautions enabled the engine to operate on gas at all at this high compression ratio when the indicator passage was more than an inch long. The authors have not only drilled an extra passage, but terminated it with a large-bore cock and even larger bore piston indicator. I suggest that the high rates of pressure rise quoted are due to detonant combustion in the passages, if not in the cylinder itself. It is well-known that detonation and even pre-ignition can be set up by indicator passages, and even at low compression ratios snifting valves are often essential.

As a very considerable range of rates of pressure rise can be obtained on oil fuel by adjustment of injection timing (and/or by using fuels of varying ignition quality) it might well be that this most useful experiment could be repeated without using gas at all. However, there is a second point which ought to receive attention and which is not referred to in the paper.

It has been shown* that with any p/v diagram derived from a time base, an error of the order of 5 per cent in initial mean effective pressure will result per deg. of phasing error. The accurate determination of the dead centre point is not easy, and both the Farnboro' and the Maihak indicator units described employ clutches. The erratic co-relation between the initial mean effective pressure obtained with the two instruments could well be due to phase errors in initial setting, slackness in the clutches or drives, and even shaft whip.

The accurate indicating of high-performance I.C. engines is extremely difficult—even the cathode-ray engine indicator is subject to phasing errors and suffers from "indirect" calibration. Messrs. Walker and Plumb are to be congratulated on undertaking the difficult task of "evaluating" a type of indicator that is cheap, simple, and robust, and it is much to be hoped that they will pursue their enquiries further.

T. D. WALSHAW,

Head of Department,
Department of Mechanical Engineering,
The Harris College,
Preston.
November 1, 1961.

VARIETY OF PAPER SIZES IN THE U.K.

SIR,—In commenting on the paper "Variety of Paper Sizes in the U.K." (THE ENGINEER, September 29, 1961, page 537) Mr. V. H. Mansell says ("Letter to the

* "Phase Errors in Time Base Indicator Diagrams," *Engineering*, July 22, 1949, page 73.

Editor," October 27, page 702) that the authors had "not given consumers any indication of how they can help both themselves and the industry by variety control." This is quite true : the purpose of the paper, as stated in the introduction, was two-fold : to find who suffers mainly from diversification and what analytical method can be employed as guidance in a simplification programme of this kind.

The first problem clearly implies that there are situations where it is by no means self-evident that consumers or users are likely to benefit from variety reduction, (indeed, there are situations where the objectives of consumers and manufacturers may be even incompatible at times), or that benefit is so marginal and so difficult to measure that a simplification programme at the consumers' end is hardly justified, particularly when it is expensive to formulate or to install. In such instances consumers will be entirely indifferent to problems of variety control and it is somewhat pointless to suggest that they should take the initiative "to help themselves and industry."

Paper sizes in the U.K. is a case in point. The case studies reported in our paper started with consumers, bearing in mind that they are the prime-movers in dictating variety by their choice and range of requirements. But it soon became apparent that stocking problems at the consumers' and merchants' end were minimal owing to speedy deliveries and that the present pricing policy of relating price to weight rather than to size was, if anything, conducive to increase in variety. Other marginal benefits to consumers, such as uniformity in filing and reduction in sizes of filing media, are often extremely difficult to measure, particularly if some of the existing media (such as cabinets) may become obsolete by the new system. This is a case, therefore, where I believe that initiative should come from manufacturers rather than from consumers.

The second problem discussed in our paper relates to methods of analysis of variety, for a broader survey of which the reader is referred to the paper "Studies in Variety Control" to be published shortly in *Management International*. Mr. Mansell asserts that classification and coding is the key method to analysis of variety and provides a basis for replenishment and stock control policies. While this is certainly true in the case of concealed variety, where classification and coding is very effective in revealing superfluous duplication and marginal differences between items, it is by no means a universal panacea. In fact, there is no universal panacea. Tools commonly used to study the effect of variety on profitability include volume-profit analysis (with the aid of break-even charts, sales income and profit distribution by products), sales effort distribution, productivity analysis of production or storage media.

Variety analysts are becoming increasingly convinced that different situations may require the application of different tools. Indeed, we have come across a number of cases (including the problem of paper sizes) where none of the tools described above was very helpful in demonstrating which sizes were decidedly more profitable to stock. In tracing the problem back to the manufacturers it was possible to suggest a suitable effective criterion for analysis (namely, the amount of scrap resulting from shearing operations). To return, therefore, to Mr. Mansell's point, the paper "Variety of Paper Sizes in the U.K." demonstrates that sometimes : (*a*) it is not enough to show that variety exists ; it is equally important to suggest who is likely to benefit most by taking action, and (*b*) conventional analytical tools (including classification and coding) sometimes fail to give us conclusive answers and other methods have to be devised.

Without further information, the example cited by Mr. Mansell in his letter is meaningless. One important piece of information missing is the relative quantities of demand for the various sizes, also what saving can be expected by cutting bigger sheets into smaller ones at the consumer's end (taking into account cost of cutting equipment, labour, material scrap in cutting, but possible saving in storage space and stock holding) compared with cut-to-size sheets supplied by the mill. The smallest sheet in the original listed variety is 9in by 11in (which suggests that Mr. Mansell's example refers more to printing rather than writing paper) and if this size is used extensively it should be noted that it cannot be cut from any size mentioned in the revised lists without the corresponding amount of shearing operations and significant material losses in trimming.

SAMUEL EILON
Imperial College of Science and Technology,
London, S.W.7.
November 1, 1961.

Books just published

Railway Electrification at Industrial Frequency
496 *pages. Illustrations. Diagrams.*
Publisher : British Transport Commission, 222, Marylebone Road, London, N.W.1.
British Railways Electrification Conference, London, 1960.
Price £5

This book contains the full text of the forty-two papers presented at the British Railways Electrification Conference, together with notes on the discussions and the authors' written answers to the more involved questions raised in the discussions. All the authors were British and the book therefore forms a review of British technique in alternating current rail traction. There is no index.
[Reply Card No. 1262]

Modern Civil Engineering Practice
493 *pages. Illustrations. Diagrams.*
Publisher : George Newnes Ltd.
Advisory Editor : Rolt Hammond, A.C.G.I., A.M.I.C.E.
Price 80*s.*

This book attempts to review current trends and practice in civil engineering and to this end twenty-one contributors describe and discuss roads, bridges, railways, tunnels, dams, nuclear power stations, mechanical equipment, as well as more general topics such as organisation within the industry, future prospects, and civil engineering as a professional career. There are ninety-six plates, many diagrams, and a subject index.
[Reply Card No. 1283]

Industrial Microbiology
286 *pages. Illustrations. Diagrams.*
Publisher : Butterworth and Co. (Publishers) Ltd.
by ANTHONY H. ROSE, Ph.D.
Price 60*s.*

This book surveys the many processes in modern industrial microbiology, and deals with the biochemical, engineering and economic principles involved in the use of micro-organisms in industrial processes. The chapters deal with chemical activities of micro-organisms, microbial technology, mass cultivation, alcoholic fermentation, acetone-butanol fermentation, organic acid production, production of antibiotics, vitamins, amino acids and gibberellins ; microbial enzymes, and micro-organisms in chemical synthesis. Each chapter has a comprehensive list of references, and the volume is completed by a bibliography and an index.
[Reply Card No. 1286]

Natural Resources in Scotland. Proceedings of a Symposium held at the Royal Society of Edinburgh, October 31—November 2, 1960.
796 *pages. Diagrams.*
Publisher : Scottish Council (Development and Industry), 1, Castle Street, Edinburgh 2.
Price 105*s.*

These papers deal with land, water, fuel and energy, mineral, fish and wildlife, forestry, and human resources in Scotland. The volume is divided into three sections: 1, basic resource facts; 2, utilisation of resources; and 3, resource administration and development. Each section includes the introductory address and the texts of the papers which are preceded by a contents list of the section. As there is no separate index for the whole volume it is difficult to locate particular information without much searching through the contents lists of the sections.
[Reply Card No. 1287]

Basic Principles of Electronics and Telecommunications
374 *pages. Diagrams.*
Publisher : George G. Harrap and Co. Ltd.
by M. D. ARMITAGE, B.Sc., A.M.I.E.E., A.Inst.P.
Price 22*s.* 6*d.*

This book is intended for the second year technical student, and gives fundamentals of electricity, magnetism, thermionic valves and transistors. Little attention is given to the construction of apparatus, the emphasis being on the physical principles concerning operation of electronic and telecommunications equipment and circuits. Chapters include introduction to electricity and magnetism, introduction to d.c. circuit calculations, power and energy, electromagnetism, electromagnetic induction, electrostatics and capacitors, introduction to alternating current, valves and transistors, amplifiers, rectification of a.c., instruments and measurements, electrochemistry, and sound and microphones. Also included are a list of standard symbols and abbreviations, appendices on elementary chemistry, valve and transistor characteristics, answers to exercises and an index.
[Reply Card No. 1288]

Safe Bind, Safe Find : The Story of Locks, Bolts and Bars
126 *pages. Illustrations. Diagrams.*
Publisher : Phoenix House Ltd.
by GARRY HOGG.
Price 12*s.* 6*d.*

This is a history of locks and such protective measures from early Egyptian times to the present day. It shows the development of various types of locks, including Roman, Yale, pin-tumbler, lever and time locks. Other chapters deal with bullion robberies, treasure chests, safes, pick-locks, safebreakers and bullion vaults. Illustrations of types of locks and safety devices, and plates of keys, locks and engraved chest locks are also included. This is a popular account for the general reader, rather than a book for the specialist. There is a short index.
[Reply Card No. 1290]

I.C.E. Presidential Address

The President of the Institution of Civil Engineers for the session 1961–62 *is Sir George McNaughton, C.B., who, until his retirement from Government service nearly two years ago, was chief engineer at the Ministries of Health and of Housing and Local Government. Last Tuesday, Sir George delivered his presidential address, in which he spoke only partly of his own field of engineering, concentrating also on " important matters which may substantially shape the future position which society and the country may be prepared to accord to the Institution and to its members." The following abstract from his address concentrates principally on this topic, and only one subject—that of possible future legislation for water conservation—is reproduced from his remarks on public health engineering.*

IN earlier days the members of the Institution were to a large extent a body of men who covered engineering in all its aspects ; they often played a prominent part in policy formation and the financial control of the works for which they were responsible either as engineers or contractors and, at times, they were not slow in conveying their views to the legislators and administrators on matters on which they considered themselves competent to express an opinion. Gradually a change of outlook came about and, since the early days of the century, the engineers began to identify themselves more and more closely with engineering only and to leave questions of policy, administration and finance to others. There have been a number of factors leading to this position. Some engineers have been so enthusiastic in regard to their engineering interests that they preferred to leave all ancillary duties to others ; some have been so specialised in a narrow field that they became incompetent to handle other matters ; some, many of them brilliant technically, appear to have been lacking in a broad general education and consequently failed to appreciate other than engineering interests. In addition it seems the engineers have been driven into the position of professional and technical advisers to others by the force of public opinion and the growing awareness that the many and varying social considerations could not be neglected and that engineering endeavour by itself could only play a contributory part in the technological development of the country. No doubt there are many other reasons which have caused the engineer to be relegated in a large degree to purely technical matters and one can only speculate as to the fundamental cause of the present position—can it be the absence of a higher standard of education in the humanities and the social sciences amongst the entrants to the profession?

The layman with whom the ultimate decision often rests is generally unable to assess engineering merits and is forced to judge the worth of a scheme on the engineer's obvious general knowledge and breadth of view. If he is lacking in these attributes it may be that, no matter how good the engineering conception may be, the scheme will receive less support than it merits. We cannot compel society to accept the engineer as one competent to express views over a wide field but we can earn the right to do so by our ability to be able to deal with all the varying aspects which arise when engineering matters are under consideration.

It is worth recording that some of our universities are apparently subscribing to this philosophy ; one has decreed that all engineering students will now take, as a subject for examination, a course in modern social and economic history and an introduction to economics in the second year. Students who wish to take honours in general engineering will include economics and politics in their third year at the end of which they will take their final examination for the ordinary degree, specialising in one of the branches of civil, mechanical or electrical engineering. In the fourth year they will spend half their time in broadening their knowledge of engineering science and the other half in the faculty of social science where they will take courses at an honours standard in economic analysis, business administration and a choice of one in industry, labour, or economic statistics. The honours examination will consist of four papers in engineering science and three papers in social science.

It is understood that several other universities now include non-engineering subjects : e.g. English, economics, aesthetics, in their degree course but, at the time of writing, no university except the one quoted above has assumed the task of training its students so widely in the humanities and social sciences. A number of them are, however, studying the position closely and it will be interesting to see the amendments made to their syllabuses within the next few years to prepare the young engineers to play their full part in the industrial development of the country.

In educational matters the Institution has endeavoured to keep abreast of the times and the general opinion is that standards are reasonably high in the technical fields which provide for many diverse engineering and allied interests. It is, however, considered by some that the standard of general education could with advantage be raised. If the Council accept the view that the future engineer should also be qualified in social science and that he should concern himself with a wide variety of non-engineering matters it is obvious that the educational standard for entrants to the profession will have to be raised in a substantial degree. No doubt a proposal of this nature will raise opposition amongst those concerned with numbers rather than with quality of the members, but I feel that, in the interests of the professional engineer as opposed to the technician, such a requirement will become inevitable in the future. It is realised that it will be no easy matter to achieve this aim. At present candidates for election to corporate membership may offer a very large number of exempting qualifications in lieu of the Institution examination and it will frequently be found that these qualifications may have been obtained on a comparatively low general educational standard. Ways and means may have to be found whereby this position can be avoided and it may take some time before all the conflicting interests are reconciled to the position.

It seems to me that, when an adequate number of engineers are in practice in joint academic qualifications in engineering, the humanities and the social sciences, society will have no option but to accept them as competent in the wider fields in which engineering operates and then the engineer will by right expect to be heard on the many complementary considerations which are vital to the success of engineering projects.

During the century the Institution has, from time to time, varied its attitude to meet the changing conditions which have come about but basically it is governed by a Charter which lays down in no uncertain terms that it is a learned society with its members elected under stringent and definite conditions. In addition there are Rules of Professional Conduct which control the conduct of members to each other and to the public at large. There is no doubt that the Charter, and its by-laws, and the conduct rules have well stood the test of time and the benefits which come about from being accepted as a learned society are substantial. Nevertheless it may be that a strict adherence to the Institution ideals will mitigate against the interests of members when they are in competition with or dealing with others whose actions, although perfectly honourable, are not so circumscribed in character. To-day more and more of our members are making their careers in government and local government services, in the nationalised industries, with contractors and other industrial organisations and there may be room for a reappraisal of the position if the Institution is to play its part towards its members in the future under such circumstances. It may be that this is not a matter for the Institution alone but that there should be a joint examination of the subject by a body representing all the chartered engineering Institutions. If, in the end, it becomes apparent that the present charters, by-laws, and conduct rules are adequate to meet modern conditions it will do much to maintain the confidence (if this is necessary) of the members in the Institution, its outlook and ideals.

Research

In the past civil engineering has suffered through there being no central organisation charged with the duty of initiating and co-ordinating research. An enormous amount of valuable work has already been done by various universities, government research organisations, contractors and private industry but there is still a very wide field of fundamental and *ad hoc* research open to an organisation commanding the substantial funds which are necessary if the best brains are to be attracted to and retained on this work and if the right laboratories and equipment are to be provided.

The Civil Engineering Research Council has recently been formed and is now assured of an income of at least £40,000 per annum over the next few years, but research is costly and a much larger sum is required if the organisation is to do all that is expected of it. To-day the Water Research Association (allied to the British Waterworks Association) has an annual income of about £80,000, and the Water Pollution Research Board of the D.S.I.R. spends approximately £120,000 per annum. Both organisations operate over a comparatively narrow field and, if the research organisation of the Institution is to cater for the whole field of civil engineering it is apparent that a very large sum of money will be required annually. Sir Herbert Manzoni has put the target figure at £250,000 per annum. Should it be forthcoming and if the organisation produces results commensurate with the expenditure involved, then the Institution and the whole engineering profession will gain increased stature, our new engineering works will reflect the application of the new techniques,

and our consulting engineers and contractors will be able to compete abroad on more advantageous terms to the benefit of the country at large.

Amalgamation of Institutions

Much has been written during the last year or two about the desirability of amalgamation or affiliation between the various chartered bodies of engineers and it is hoped that interest in this absorbing subject will continue unabated. Sir Hugh Beaver, in the sixth Graham Clark lecture stated that, as long ago as 1929, it was estimated that there were more than 100 institutions, institutes, societies and associations devoted more or less directly to the science, subject and practice of engineering, and that the number has in all probability greatly increased since then. I feel that this Institution must bear its fair share of responsibility for the splintering or fragmentation which has taken place especially towards the end of last century and during the early years of this one.

The field of civil engineering has become so wide that any one engineer can only hope to become an expert in a small section of it in a normal lifetime. Consequently this has led, in an ever-increasing degree, to specialisation, and it is now apparent that the Institution did not, until recent years, make any substantial endeavours to allow for the many and divergent interests which arose. To-day the position is different ; the specialists are well catered for in the various divisional boards and specialist groups and papers are welcomed on a wide variety of subjects. Nevertheless the damage has been done. Many of the splinter organisations are now in their own right important and highly respected bodies doing a first-class job and it is no easy matter to propound a solution to a position which bewilders the layman and leads to the engineers of the country speaking with many and often contradictory voices. Other organisations which are able to put up a united front have shown that their views carry weight, and if the 200,000 engineers of different categories are to obtain the place in society which their work merits, it is apparent that early action is necessary to remedy the position as it exists to-day. Although most engineers agree with this view there are substantial differences of opinion about the correct solution and how best it can be achieved. Many of us thought that the first step might be to combine the various chartered civil engineering societies with this Institution. At the same time the Mechanical and Electrical Institutions might be expected to proceed in a similar manner in respect of their specialised interests.

Consequently a new school of thought is gaining a substantial degree of acceptance. It is that the Civil, the Mechanical, and the Electrical Institutions should, if they agree, combine together to form one Institution of Chartered Engineers which would be so powerful that the other chartered bodies could not afford to stand outside. Others, who, whilst accepting the ideal of one all-purpose Institution, hold that the time is not yet ripe for such a bold and far-reaching step and they propound an over-riding high level co-ordinating board which would speak for the three major Institutions on all matters of public interest and policy, leaving it to the individual Institutions to continue as at present and to achieve appropriate amalgamations and affiliations as may be desirable in their respective spheres. It is thought there is a substantial body of opinion in the three Councils in favour of this suggestion. I am in favour of it, not as a final solution, but as a means of bringing the Institutions closer together in the hope that it will be possible to unite the three Institutions into one body in the not too distant future.

National Policy for Water Conservation

Increasing demand for water by the domestic consumers, by industry and by agriculture in its various forms, the lessening number of sources which can be developed economically, the pollution of the rivers and the whole water economy (in regard to both clean and dirty water) has caused the central authority, the Ministry of Housing and Local Government, to consider how best a national policy of water conservation and use may be achieved. In a memorandum prepared by the Ministry in April this year it is stated that new and far-reaching legislation is proposed in regard to the whole water economy and it is contemplated that a Bill will shortly be put before Parliament under which Water Conservation Authorities will be established to control the economy of each river basin or groups of basins. The proposals are still in an early stage but it is understood that the Minister has opened confidential discussion with the representatives of affected interests, both public and private. If, in the end, he promotes the Bill with proposals in accordance with the memorandum, the water Conservation Authorities will, in brief, become responsible for :

1. The keeping of an up-to-date hydrological survey for each area, including the assessment of water resources and potentialities (both surface and underground).
2. The preparation of an overall plan for the development of resources.
3. The control and development of resources including the construction and operations of regulating works.
4. The allocation of water between the various users by a licensing system.
5. In suitable circumstances the recharge of underground aquifers.
6. Reviewing and varying the discharge of compensation water.
7. Where appropriate, the transfer of water between water conservation areas.
8. The control of pollution both of surface and underground water.
9. Land drainage and flood prevention.
10. Certain navigation questions.
11. The administration of fishing legislation.

(In many matters there will be a right of appeal to the appropriate central Government authority.)

Looked at from the purely engineering point of view one can only accept the technical proposals as necessary if the water economy of the country is to be fully considered and controlled at all stages. The underlying philosophy is not new ; most engineers who have been concerned with water conservation and use in the past will agree that in general some broad regard has been had to most of the matters covered but this is the first time an endeavour has been made to embody them in detail in legislation and to allocate to some organisation the duty of seeing that they are fully implemented. One would anticipate that although the technical proposals may be generally accepted as necessary there will be long and controversial discussions in Parliament as to the policy and administrative forms under which the control will be exercised. There are a very large number of conflicting interests involved, the settlement of financial considerations will be difficult and complicated, and no doubt there will be much argument about the responsibilities which may properly be borne by the Central Authority, the Water Conservation Organisations (in whatever form they ultimately emerge) and the many and varied user interests.

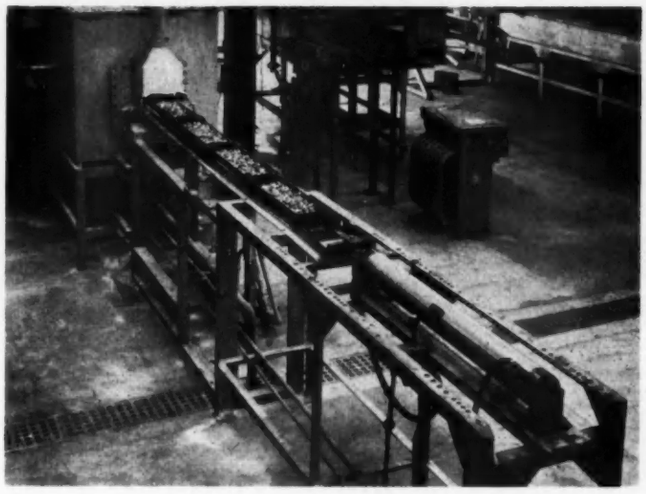
Production by Moulding

THERE has been announced by the Birmingham Small Arms Company Ltd., the formation of two new divisions, the General Engineering Division (comprising B.S.A. Guns Ltd., Carbodies Ltd., Monochrome Ltd., and B.S.A. (Redditch) Ltd., the latter a new company incorporating a factory formerly operated by B.S.A. Motor Cycles Ltd.) and the Metal Components Division (consisting of B.S.A. Metal Powders Ltd., B.S.A. Sintered Components Ltd., B.S.A. Precision Castings Ltd., and Idoson Motor Cylinder Company Ltd.).

B.S.A. Sintered Components is the new name for an existing unit of the group, Metal and Plastic Components (originally Compacts) Ltd., and as it suggests, the firm is engaged in the production of components by sintering the products of B.S.A. Metal Powders Ltd. The production of parts by sintering has been performed in the Group since 1943, initially for bushes of porous bronze with oil-retaining qualities, although the firm specialising on the process did not commence a separate existence until 1947. Although there is a separate firm engaged in the production of powders, which are marketed under the name " Cosint," the process and the materials have in fact been developed together, and a requirement on which particular emphasis was laid in the evolution of metal powders was that they should allow the final configuration to be attained by pressing and sintering, i.e. that distortion during sintering should not demand a subsequent coining process. The elimination of a second cycle of pressing and sintering clearly reduces the cost of the product, and the same object is sought in another manner by the use of a particularly high temperature, nominally 1300 deg. Cent., in the sintering process ; we are advised that at this temperature diffusion proceeds in the compact at a rate $2^{180/10}$ =33,000 times that at a temperature 150 deg. Cent. lower, and it is, therefore, possible to form mixtures which are virtually alloys, but, if melted, would not form a homogeneous matrix. As an example, B.S.A. Metal Powders produce a stainless steel powder which M.P.C. improved by the addition of nickel. This material (code SA 38/20) has improved " green strength," is softer and, therefore, easier to press, and it machines more readily than the original sintered stainless steel. Because nickel powder is cheaper than stainless steel powder, the above qualities are achieved at a lower powder cost. Tensile strength is 26/8 tons square inch with 3 per cent elongation.

Also in the range of high strength steels sintered at 1330 deg. Cent. is nickel molybdenum steel (code MN 18/60). This material has a tensile strength of 55 to 65 tons square inch and 4 per cent elongation and, again, is produced by one pressing and one sintering operation. This material has the same furnace shrinkage characteristics as sintered nickel steel and components from both materials give the same finished component size. This is a great advantage when selling a material which may require a little more than sintered nickel steel strength : a customer can, from one set of tools, try both materials. In the " as sintered " condition, nickel molybdenum steel is unmachineable and this characteristic can be useful when the product requires a high resistance to wear. If machining is necessary, an annealing operation can be carried out quite cheaply and a further furnace

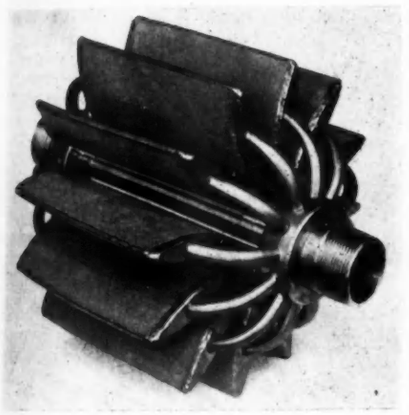
Mass-produced components for which powder metallurgy gives the lowest delivered price



"Boats" containing small parts are linked together by pins and pushed through an oven into a controlled atmosphere furnace. At the far end another air motor pulls the train forward

operation will put the material back into the unmachineable condition.

Mixtures of iron/copper were the original materials for use on structural parts and are well known in France and Germany. B.S.A. use the full range of iron/copper mixes, but, due to certain furnace variations, size control on iron/copper and iron/copper/carbon are difficult. M.P.C. introduced an extension to the iron-copper range two years ago and this material bears the code CF.22. This material contains nickel/copper/carbon and manganese and gives a tensile strength of 19 to 24 tons square inch with 1 per cent minimum elongation.



Stainless steel filter with porous elements formed by pressing, sintering and coining

This strength is about 5 to 8 tons greater than that achieved by iron/copper mixes and, on sintering, the CF.22 components are very stable. Iron/copper materials cannot be hardened successfully, but CF.22 can be cyanide-hardened, carbo-nitrated or B.F. hardened. This new material is as much as 20 per cent cheaper than nickel steel, NS 5/20.

The latest addition to B.S.A. sintered steels is CN.67 and this is claimed to be the "break through" for low-sintered steels. CN.67 gives a tensile strength of 25 to 27 tons square inch with 4 per cent elongation and, because of the low sintering temperature (1150 deg. Cent.) the process costs are lower than sintered nickel steels. Once again, there is very little movement on sintering with this material which means greater dimensional control and less distortion than with components sintered at 1330 deg. Cent.

In the field of bronzes also, B.S.A. has introduced new materials, but, although P.V. factors and strengths have been improved, costs have been a major problem. The market in which high duty bronze (code HD.72) has been successful is that where loadings are higher than the conventional self-lubricating bronzes. An example of this is motor-car and motor-cycle gear box bushes and telescopic fork bushes for motor-cycles. A new addition to the bronze range of sintered materials is a nickel bronze (code NB 10/2) which has a higher compressive strength than HD.72 and also a higher tensile strength (13 to 15 tons square inch against 8 to 9 tons square inch).

In the field of nuclear engineering, B.S.A. has developed a boron-iron alloy for use as inserts in control rods which has 8 per cent of boron, where normal boron steels are limited to approximately 1 per cent. Control rod inserts sintered from boron-iron alloy require no machining and are held to tight tolerances. Castings of boron steel can achieve about 3 per cent boron, but, if inserts were cast from this material, the casting would still require grinding, which is a very difficult operation on this material. This boron-iron can also be manufactured in the form of spheres for "scram" shut-down, and has a higher boron content than conventionally-produced spheres, so that the components are lighter than those produced from solid boron steels.

The properties of sintered materials are listed in the table, from which there are omitted two irons of high permeability used for intricately shaped armatures. The use of a high sintering temperature is, of course, not without problems, and in fact the first successful high temperature sintering furnace was one built by B.S.A. for its own use. The furnaces are heated by electric elements and charged with a controlled atmosphere: normally, the wax which is included in the powder to hold the pressing together is burnt off in a preliminary oven containing air. It was found that the trays, or "boats," in which small components are passed through the furnace, had a short life due to their being unable, when hot, to stand the load imposed by coupling a number of boats into a train and driving it from one end; this difficulty has been overcome by simultaneously pulling at one end and pushing at the other, so that the boats near the middle, which are hottest, are only lightly stressed.

The other companies in the new Metal Components Division also exploit the advantages implicit in the production of components without the wastage due to orthodox machining. B.S.A. Precision Castings Ltd. execute the "lost wax" process, and has extended the size range for regular production up to or beyond 50 lb, while the other foundry, that of Idoson Motor Cylinder Company Ltd., uses shell moulding to cast finned cylinders and other parts ranging between ounces and 60 lb in weight within tolerances ranging down to ±0·008in.

Properties of Sintered Materials

Code	Density gm/c.c.	U.T.S. tons per square inch	Elongation per cent	Hardness, V.P.N.	Load-carrying capacity (P.V.)	Remarks
NICKEL STEELS						
NS 5/20	7·0	26–32	6–10	120–180		As sintered
NS 5/20		60	1	450–550		Cyanide hardened
NS 5/80	7·0	38–44	2	180–220		Can be cyanide hardened or plated
NICKEL MOLYBDENUM STEELS						
MN 18/60	7·0	55–65	4	240–270		—
MN 25/50	7·0	45–55	4	200–240	—	—
MILD STEELS						
MS 20/68	6·8	12–14	2	80–120	—	Can be cyanide hardened or plated
MS 100/60	6·0	12–14	1	80–120		Replaces cast iron
MS 20/60	5–8	8–10	1	30–60	—	Oil-retaining bearing material
STEEL						
CN 67	>6·65	25–27	4	*c.* 130	—	—
ALLOY IRONS						
CF 22	6·0	19–24	1	70–80	—	—
CF 10	5·8	16–18	2	60–120	—	Meets British Railways Specification 145
CF 5	5·8	14–16	1	50–80	—	—
CF 2	5·8	12–14	1	30–50	—	—
STAINLESS STEELS						
SA 38	6·3	21–24	4	7·0	—	Sintered austenitic
SA 38/20	7·0	26–28	3	180–250	—	Sintered austenitic, nickel modified
SM 56	6·7	22–26	3	180–250	—	Sintered martensitic
BRONZES						
PA 82	8·2	18	20	65	—	—
SD 60	6·0	4–5	2	*c.* 20	50,000	Need occasional addition of oil
HD 72	7·2	8–9	5	*c.* 54	434,000	Need constant supply of oil
NB 10/2	—	>12	—	—	>434,000	(Nickel bronze) Properties still under investigation
BRASS						
SB 75	7·5	10–12	10	40–60	—	—
COPPER						
SC 83	8·3	7–9	6–9	45	—	For intricately shaped commutators
COPPER NICKEL						
SM 65	6·5	10	8	—	—	For intricately shaped parts with high corrosion resistance

SHORTER REPORTS

Foundation Design and Construction

ON Thursday, November 2, an informal discussion with the above title was held at the Institution of Civil Engineers. The discussion was introduced by D. J. Henkel of Imperial College, whose introductory note is reproduced in the following paragraphs.

The growing demand for taller buildings, associated very often with deep excavations, has brought into prominence some of the uncertainties associated with foundation design and construction. The overall requirements of foundation design are that there should be an adequate factor of safety against catastrophic failure and also that the deformations under working loads should not affect adversely the functional performance of the particular structure. It would appear that the major difficulties at the present time are those associated with the deformations under working loads, but in some cases no sharp distinction can be made between the two aspects of the problem.

Any useful discussion should centre on the unsolved problems, but it should not be allowed to obscure the fact that for a wide range of conditions reasonably accurate forecasts of foundation behaviour can be made. It must also be appreciated that foundation problems, depending as they do on the local geology, tend to be regional and experience gained in one area cannot necessarily be applied in another area where superficially the problems appear to be similar.

The main foundation problems confronting the Civil Engineer cannot be divided into neat separate compartments but, for the purpose of discussion, it is suggested that they be divided broadly into (*a*) deformation problems and (*b*) stability problems, although some overlap is inevitable.

DEFORMATION PROBLEMS

Estimation of settlements on sands and gravels.—The estimation of settlements of foundations on sands and gravels still presents major problems. Very little satisfactory field data on settlements combined with the results of adequate site investigations are available. Two widely used empirical procedures are those developed respectively by Buisman, using the "Dutch Cone" test, and Terzaghi, using the Raymond Standard Penetration Test. In many circumstances these two procedures lead to widely different estimates of settlement. An additional difficulty is that very often the "Standard Penetration Test" is carried out under conditions which depart radically from the original test procedures.

This problem is of particular importance in large heavy structures where decisions have to be made about the necessity for piling or means of artificially compacting deep beds of sand.

Piled foundations.—In the literature on piled foundations great emphasis has been placed on the performance of individual test piles in relation to the properties of the soil. While some progress has been made in this field it is clear that a great deal more needs to be known about the precise way the pile loads are transferred to the ground both under test and working conditions. In particular the benefit to be derived from the taper piles needs greater attention.

The concentration on the behaviour of individual piles has, however, obscured to some extent the fact that in practice the main concern is with the deformation of the pile group, very often associated with a pile cap or slab on the ground surface. Recent work by Whitaker at the Building Research Station has been valuable in drawing attention to this problem, and it would appear that a better understanding of the combined action of the pile group and cap may result in substantial economies in design.

Enlarged base bored piles in London Clay.—Enlarged base bored piles are being used fairly extensively in the London Clay in order to increase the bearing capacity of an individual pile. The limited published test results on individual piles suggest that design methods appropriate to foundations of this type must be related to the deformations under working loads. It appears at this stage that the deformations of these enlarged base piles are rather larger than would have been expected from the extrapolation of data obtained from parallel-sided bored piles. It would be very useful if all the test data on the enlarged base piles could be assembled so that a critical assessment of their behaviour could be made.

Building on sites underlain by old mine workings.—The present tendency for the erection of comparatively tall buildings on sites underlain by old mine workings raises complex problems about the possibility of preventing large deformations in the ground beneath the building. These problems are particularly severe in regions where the old workings are shallow and no records of the mining operations are in existence.

Deep excavation.—The making of deep excavations involves a large number of separate problems. The stability of the excavation sides and bottom is, of course, of great importance but deformation of the ground in the vicinity of the excavation must also be limited to avoid damaging adjacent structures.

Recent developments in the use of reinforced concrete diaphragm walls cast in a trench supported by drilling mud require critical examination both from the point of view of the strength of the wall and the effects of the drilling mud on the soil in the vicinity of the wall.

Deep excavations will normally remain open for a considerable time before the final propping of the retaining walls is completed. The variation of the earth pressure on the wall both with time and with the amount of yield permitted deserves full consideration.

Severe deformation problems associated with deep excavations arise when the design calls for an isolated tall building block placed on an "island" foundation in the middle of an extensive deep basement. The final foundation pressures over most of the area of the basement will be very much less than the original overburden pressure while, under the tall building block, the foundation pressure may be in excess of the original overburden pressure. Difficulties associated with the heave of the ground in the lightly-loaded areas and settlement below the heavily-loaded areas have to be overcome.

STABILITY PROBLEMS

Structures on sloping ground.—The placing of structures on clay slopes which are close to limiting equilibrium raises important questions of overall stability as opposed to the local conditions in the immediate vicinity of the foundations.

The effects of creep of the soil and the possible development of landslides require careful study. In soft clays the driving of piles may lead to a substantial increase in pore water pressure with a consequent reduction in the shear strength of the clay and a catastrophic landslide might occur.

Large-diameter piles in cohesionless materials.—Recent work in France and Germany suggests that the end bearing capacity of large diameter piles in sands may be considerably lower than might be expected from the results of exploratory small-diameter soundings. Results of experience of this problem would be useful.

European Satellite Launcher

THERE took place last week at Lancaster House in London a conference to discuss arrangements for establishing the proposed organisation to construct and develop a space launcher (rocket booster) in Europe. It has been announced that a draft convention defining a programme, which would result in a vehicle of which the three stages would be the responsibility of Great Britain, France, and the Federal Republic of Germany respectively being fired for the first time at Woomera in 1965, has been proposed for the consideration of the governments also of Australia, Belgium, Denmark, the Netherlands, Italy and Spain. The governments of Great Britain and France will ask the remainder to decide within three weeks whether they will sign the convention. At the conference there were present observers from Norway, Sweden, Switzerland, the Council of Europe and the Preparatory Commission of the European Space Research Organisation.

If the proposed organisation is instituted, the actual work will be done on its behalf by means of contracts emanating either from the organisation itself or the governments of member states. Technical information required in the course of the work would be freely exchanged between member countries. It is envisaged that there would be employed on such contracts nationals of each member state.

350MW Steam Turbo-Generators for Australia

Two 350MW steam turbo-generators are to be designed and built by The English Electric Company Ltd., for installation in the Munmorah power station, New South Wales, Australia. The order, worth about £4,000,000, was placed by The Electricity Commission of New South Wales.

Munmorah is a new coal-fired station which will be sited between Lake Munmorah (from which the cooling water will be drawn) and Lake Budgewoi. It will be about 10 miles from the Vales Point power station where three English Electric 200MW sets are to be installed.

At Munmorah the first 350MW set is scheduled to go into commercial operation in November, 1966, and the second set a year later. An interesting aspect of the ordering of generating sets of this size is that each will have the same capacity as the total capacity of all the new generating plant installed in New South Wales in the year ended June, 1960.

Each set, consisting of a 3000 r.p.m. single-line reheat steam turbine and a hydrogen-cooled alternator, will be similar to the English Electric 350MW units now on order for the C.E.G.B. Drakelow-C and Blyth-B power stations; some details are tabulated below. The turbines will be made at the company's Rugby Works and the alternators at Stafford.

Turbine :	
Steam pressure at t.s.v.	2300 lb per square inch gauge
Total temperature at t.s.v. ...	1050 deg. Fah.
Re-heat temperature	1000 deg. Fah.
Vacuum at C.M.E.R.	28·1in Hg. (Bar=30in)
Final feed temperature at C.M.E.R.	485 deg. Fah.
Alternator :	
C.M.R.	350MW at 0·9 p.f.
Coolant gas pressure	45 lb per square inch gauge
Electrical conditions	Three-phase 50 c/s, 17·5kV

Care of Wire Ropes

AT the recent opening of the research centre of British Ropes Ltd., at Doncaster, which was noted in our last issue, the Press were shown a preview of a film which the company has made.

The film is called "If Ropes Could Talk," and its aim is not that of advertising, but the more practical one of giving practical advice and instruction on the selection and use of wire rope. The film runs for twenty-one minutes. It begins with a short sequence on wire rope in the making, and then on its various applications. To demonstrate methods of looking after ropes in use, the ropes fitted to a dragline excavator are shown and several different rope faults, due partly to bad maintenance and partly to incorrect handling of the machine itself, and the way these rope faults are overcome are all depicted. The many different types of wire rope are explained and the correct information to be given when ordering a new rope is suggested later in the film.

Importation of Methane for Town Gas Supply

LAST week the Minister of Power, Mr. R. Wood, announced that approval had been given to the scheme proposed by the Gas Council for the importation of methane from the Sahara. This decision was made after the Minister had taken into account the urgent need for the gas industry to reduce its costs of production, the technical advantages of methane, and the relatively small capital cost the project would involve.

In the course of a press conference following this announcement, Sir Henry Jones, chairman of the Gas Council, gave some further details of the project, which will cost the gas industry almost £18,000,000. He emphasised that its main object was to reduce gas production costs with a view to expanding the industry and giving better services to consumers. Under the scheme methane gas would be delivered to area board gas works at 7½d. a therm and be used mainly for reforming and enrichment of lean gas enabling town gas to be produced at a cost of 8½d. a therm. He could give no indication as to whether the savings effected would affect the price of gas as delivered to consumers.

Under the scheme which was outlined by Sir Henry, it is hoped that in about 2¼ years two specially constructed tankers will begin to operate in a service delivering up to 345,000,000 therms of methane per year to a new terminal to be built at Canvey Island in Essex. These deliveries will, it is expected, provide about 10 per cent of the total gas supplies in 1964–65. By the use of methane the gas boards will need about 800,000 tons of coal less a year (out of the estimated annual requirements of 19,000,000 tons) and a saving of over 400,000 tons of oil products will also be effected.

Under the scheme gas from the Hassi R'Mel field in the Sahara will be delivered by pipeline to Port Arzew, near Oran, where it will be liquefied in a plant to be built by the Compagnie Algerienne de Methane Liquide at a cost of some £14,000,000. The two new tankers to be built to deliver the liquid methane to Canvey Island will each have a capacity of about 12,000 tons and their service speed will be 17¼ knots. These special vessels, designed to carry their cargo at a temperature of −250 deg. Fah., are to be built by Vickers-Armstrongs Ltd. and Harland and Wolff Ltd., to the requirements of Conch International Methane Ltd., and they will cost about £7,000,000. The ships will be chartered by British Methane Ltd.—a company owned jointly by the Gas Council and Conch International—on a long-term basis.

At Canvey Island the liquid methane will be stored in tanks of the North Thames Gas Board whence it will be pumped, as required, to a regasification plant to be built nearby. From this plant the gas will be transported in a new 18in gas main to works of seven of the twelve area gas boards—the North Thames, Eastern, South Eastern, Southern, East Midlands, West Midlands, and the North Western—each of which will be responsible for the main laid in its area.

Electrolytic Machining

AMONGST the equipment to be demonstrated at an exhibition in the showrooms of Soag Machine Tools Ltd., Juxon Street, London, S.E.11., from November 14 to 24 next will be models of the "Contelyt" electrolytic tool servicing and production machinery equipment made by Maschinenfabrik Uerkheim of Aargau, Switzerland. On these machines, one of which we illustrate here, sharpening of carbide tools or the machining of carbide and other difficult metals is effected by an electro-chemical process, with the contact wheel serving as the cathode, the workpiece as the anode and the coolant fluid as the electrolyte. The contact wheels have an eccentric groove in their working surfaces which serves to spread the electrolyte both in the direction of rotation and back and forth across the work surface. This ensures an effective film of electrolyte and prevents sparking at the edges, as the grooves are confined to within the wheel

Electrolytic tool servicing and batch production machine for work up to 2½in high

surface. In addition to its electrical function and distribution of electrolyte, a contact wheel also serves to remove the oxide and salts which form on the contact area as the metal is dissolved by the electro chemical process.

Each machine is a self-contained unit with the generator housed in the base, and automatic voltage control equipment ensures that the generator produces the optimum current values to suit working conditions. Three models of machine are available, the smallest being suitable for sharpening tipped tools up to 1½in high. The second, that illustrated, is a production machine with an oscillating spindle for batch machining and for tipped tools up to 2½in high. The third machine has duplex rotary tables for batch production.

It is stated that with an output of 80A to 100A from the generator one of these machines can remove up to 100 cubic millimetres of material from a 1 square centimetre surface in a minute ; with a corresponding increase in generator output 200 cubic millimetres can be removed from 2 square centimetres surface or 300 cubic millimetres from a 3 square centimetre surface in the same time. The surface finish achieved is claimed to be of the order of 10 micro inches.

[Reply Card No. 1331]

Ceramic-Cased Tunnel Diodes

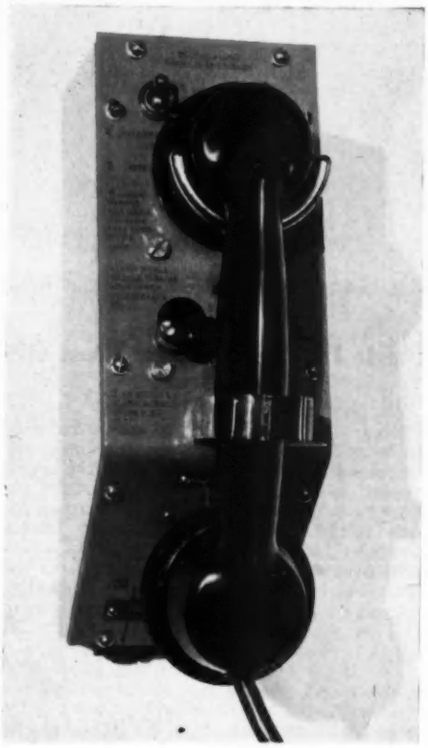
THE operating frequency of tunnel diodes has been raised by a technique of miniature ceramic encapsulation developed by Standard Telephones and Cables Ltd., Connaught House, Aldwych, London, W.C.2. A diameter of only 5·6mm (less connection tabs), and a tab-ended configuration have reduced their inductance to such an extent that a typical limiting frequency of oscillation of 900 Mc/s is now attainable. A single diode version, JK30A (illustrated), is now in production to meet the requirements of high-speed switching circuits and of oscillators at frequencies higher than 750 Mc/s. It is being followed by a new version incorporating a matched pair of tunnel diodes forming a single integral unit having three tabs. These units are matched for peak current and capacitance and are intended for applications in the computer field. They may be used in high-speed logic and counting circuits or as the threshhold amplifier/gate at the input of a pulse amplifier.

[Reply Card No. 1344]

Miniature ceramic-cased tunnel diode in a low-inductance tab-ended configuration for u.h.f. working

Marine Alarm Generator

A TWO-TONE radiotelephony alarm signal generator is now being fitted in many British fishing vessels and small craft by The Marconi International Marine Communication Company Ltd., Chelmsford, following the recommendation by the Ministry of Transport that all United Kingdom ships carrying radiotelephony apparatus should be fitted with alarm generating equipment by January 1, 1962. To bring the device into operation, the operator starts up the associated transmitter, tuned to the international

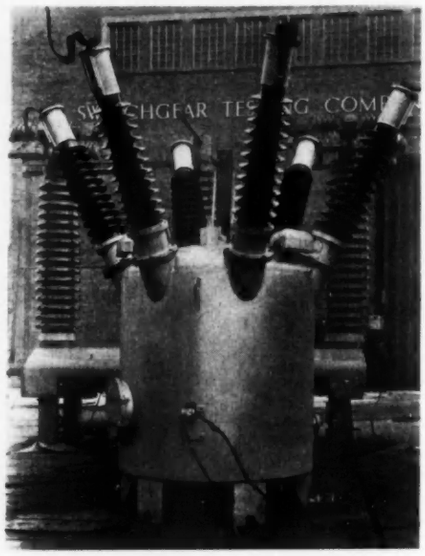


Two-tone generator for distress signals on the marine intermediate frequency radiotelephony band

radiotelephone distress frequency of 2182 kc/s, switches on the alarm generator with the telephone handset clipped on to it as seen in the illustration, and pulls the alarm knob. The two-tone signal—alternating tones of 1300 c/s and 2200 c/s—each tone lasting for 250 milliseconds—is generated for approximately thirty to sixty seconds and the verbal distress message can then be transmitted simply by disengaging the handset and speaking into it. The unit is powered by the 24V battery supply in the vessel and delivers 12mW into a 300 ohm loudspeaker which feeds the signal into the microphone of the handset. This arrangement enables the signal to be monitored aurally while transmission is taking place.

[Reply Card No. 1325]

SHORTER REPORTS *(Continued)*



Single-tank bulk-oil circuit breaker for 132kV three-phase on test in Manchester

Single-Tank 132kV Three-Phase Oil Circuit Breaker

WE illustrate the "JB431" circuit breaker, which is the latest addition to the JB-range of single-tank bulk-oil circuit breakers made by Associated Electrical Industries Ltd. The circuit breaker, shown here, has been successfully proved for 2500MVA at 132kV by short-circuit tests carried out at the Switchgear Testing Company Ltd., Manchester. This new equipment incorporates experience derived from the first British 132kV, three-phase, single-tank bulk-oil circuit breaker, which was produced in 1953 at the Willesden switchgear factory of B.T.H. (now A.E.I.).

The JB431 breaker needs only about 1000 gallons of oil. As all three phases are enclosed in a single tank, without interphase barriers, the space for maintenance inside the tank is greater than in the usual three-tank circuit breaker. Maintenance can be carried out at the same time on all three phases, regardless of weather conditions.

Each of the arc interrupters in the circuit breaker is shunted by a linear, wire-wound resistor and the full fault current of 10·9kA is interrupted in less than three cycles. The impulse withstand level is 650kV.

Seventeen of these JB431 circuit breakers are being supplied for the Cameron Highlands scheme of the C.E.B., Malaya.

[Reply Card No. 1358]

Data Processing System Developments

INCREASED storage and faster output printing are some of the features available as alternatives to the standard specification for all future orders for the "Emidec" 1100 data processing system of E.M.I. Electronics, Ltd., Hayes, Middlesex. The capacity of the fast access magnetic core store is increased from 1024 to 4096 words, while the introduction of the "E.M.I.-Anelex" printer raises printing speed from 300 to almost 1000 lines per minute. This is a hammer printer with a print roll made up of continuously-revolving discs each containing 66 characters. With the print roll operating at 1000 r.p.m., output is 740 lines per minute, with five carbon copies, and higher speeds are obtainable by changing two pulleys. Forms up to 19in wide, with a line width of between 120 and 160 characters, according to model, are handled.

Use of the "Ampex" TM2 magnetic tape transport, operating at 150in per second, has doubled the peak data rate to or from magnetic tape (now 40,000 characters per second), and the density of information has been increased so that there are over 7,000,000 characters on a reel of tape.

[Reply Card No. 1337]

1961 Amendments to Wiring Regulations

To take account of recent changes in British Standards, The Institution of Electrical Engineers has issued the "1961 Amendments to the Thirteenth Edition of the Wiring Regulations."* Most of the amendments are concerned with provisions for the use of armoured P.V.C.-insulated cables to British Standard 3346 : 1961. A prominent innovation in this Standard is the recognition of aluminium conductors (to B.S. 2791 : 1956) as an alternative to copper conductors and, accordingly, the 1961 amendments introduce requirements for the installation of such conductors. However the amended regulations do not recognise the use of aluminium conductors of cross-sectional area 0·0225 square inch (7/·064in) or less. Tables are included giving current ratings of armoured P.V.C.-insulated cables having either copper or aluminium conductors and installed in air, or in underground ducts or direct in the ground. The amendments also take account of the revised B.S. 2004 : 1961 "P.V.C.-Insulated Cables and Flexible Cords" which also allows for the use of aluminium instead of copper conductors.

A series of three new British Standards for heat-resisting cables and flexible cords were completed this year, to replace the existing B.S. 1327 : 1946 "Rubber-Insulated Asbestos-Proved Flexible Cords." The new Standards deal with cables and flexible cords insulated with silicone rubber, butyl rubber with heat resisting fibre layer, and varnished-cambric and heat-resisting fibre ; requirements for the choice and installation of these cables are given in the 1961 amendments.

All the fifteen European countries that are members of the International Commission on Rules for the Approval of Electrical Equipment (the C.E.E.), including the United Kingdom, have agreed that the earthing core in cables and flexible cords should be identified by a combination of the colours green and yellow—either as an alternative to the existing colour code or as the sole national standard. Accordingly the 1961 amendments now recognise the use of green and yellow as an alternative to green which is the existing British code. The C.E.E. has not yet reached full agreement on identification of other items in flexible cable and cords ; the colours red and black are still the only ones recognised, in the I.E.E. regulations, for identifying the live and neutral cores respectively.

As a further aid to European standardisation, a new definition of the term "extra-low voltage" has been introduced in the 1961 Amendments which is substantially in accord with the definition adopted in the C.E.E. member-countries.

The Regulations with 1961 Amendments have been approved by the Minister of Power and the Secretary of State for Scotland for the purpose of the Electricity Supply Regulations, 1937.

* "1961 Amendments to the Thirteenth Edition of the Regulations for the Electrical Equipment of Buildings." I.E.E., Savoy Place, London, W.C.2. Price 2s. 6d.

Gas Blowers for Dungeness

EIGHT gas blowers are being manufactured by the heavy plant division of Associated Electrical Industries Ltd. for installation in the nuclear power station now being built at Dungeness by the Nuclear Power Group, for the Central Electricity Generating Board. The station will have a total net electrical output of 550MW from two reactors. The reactor gas circuit will operate at 300 lb per square inch, and the gas temperatures at the inlet and outlet of each reactor will be 250 deg. Cent. and 410 deg. Cent. respectively.

Each blower, a single-stage overhung axial machine driven by an A.E.I. back-pressure steam turbine will absorb about 9000 h.p. at normal speed and will be capable of dealing with 1¼ tons of carbon dioxide per second. The blower casings will be spherical with a diameter of approximately 15ft and will have four flanged branch-openings of 6ft 6in diameter. To prevent contaminated gas leaking to the atmosphere, running seals (of the oil-fed face type) will be fitted between the impeller and the first bearing, and a stationary seal arrangement will enable full maintenance, including removal of the main driving shafts, to be carried out without reducing the circuit gas pressure.

A pony motor, rated 300 h.p., 3·3kV, three-phase, 50 c/s, will be installed with each unit, in line between the driving turbine and the blower. The motors will be two-speed machines arranged to drive either at 500 r.p.m. with full gas pressure or at 1000 r.p.m. at atmospheric pressure, and each will have two electrically-driven closed-circuit cooling fans. A non-reversing clutch, built-in with each blower, will automatically prevent reverse gas-flow from driving either the pony motor or the turbine. For each blower unit a separate oil system including tanks, pumps, filters, coolers and strainers will provide both lubricating oil and control oil for the driving turbine, pony motor and blower.

The driving turbines will operate on the total high-pressure steam output from the boilers ;

Gas blower for Dungeness nuclear power station. The inner entry-piece, part of the blower installation, is here shown being bored on a machine equipped with A.E.I. tracer control

after passing out, the steam will be returned for re-heating before joining the steam flow to the main turbine generators. Full control of the circuit gas will be obtained by speed variation on the blower turbines ; when balanced loads have been achieved, all four units associated with either reactor can be operated by means of a common control system.

Here we illustrate the inner entry-piece being bored on a machine fitted with A.E.I. tracer control equipment. This part will be fitted into the 6ft 6in internal-diameter driving-flange of the spherical blower-casing and is designed to withstand the full working gas-pressure, at the same time carrying the complete housing for the blower shaft, seal and rotating parts.

[Reply Card No. 1357]

BEAMA Golden Jubilee Dinner

THE Prime Minister, the Rt. Hon. Harold Macmillan, M.P., was the principal guest at the golden jubilee dinner of the British Electrical and Allied Manufacturers' Association in London on October 31.

Proposing the toast of the electrical and allied manufacturing industry Mr. Macmillan paid a tribute to the healthy growth of the industry in the fifty years of BEAMA's history. He acknowledged that the industry was now earning more than £300 million of foreign exchange per year and that there had recently been a marked increase in exports to Europe. This standard of performance was particularly important at present because Great Britain's net balance of "invisible" earnings abroad had decreased in the last few years. The industry had many achievements to its credit, including the world's biggest civil nuclear power programme and a number of technical advances in electronics.

Speaking of the country's economic difficulties Mr. Macmillan said that, although planning was not always in fashion, it was now becoming fashionable and that Britian must make a pragmatic approach to the problems of to-day. What industry now needed was to establish some form of self discipline and partnership to take the place of the harsher disciplines of unemployment that prevailed in the 1930's. In proposing the toast, Mr. Macmillan concluded by expressing his confidence that the electrical industry was sufficiently well-organised and buoyant to accept the challenge of the Common Market and to play a prominent part in the development of the underdeveloped countries.

In his response to the toast Lord Chandos, chairman of Associated Electrical Industries Ltd., commented on some of the problems facing the electrical industry. On the difficulties of financing its expansion programmes Lord Chandos said : "The electrical industry is one of the greatest sponges of capital that you can imagine.... In general, the truth is that man's ingenuity has outrun his ability to finance his inventions. We in this industry have to spend vast sums upon research and development, upon plant and equipment. At the same time, the conditions under which we trade are becoming increasingly tight ; profit margins are under very severe pressure. The return on the risk capital has been falling steadily in the last few years. The prospects of Great Britain joining the Common Market, would appear to most of us likely to intensify competition. We are all trying flat-out to improve our efficiency and to increase our profits, so that we can sustain the large bill for research and development which we must carry if we are to remain in the forefront of progress in this ever-advancing dynamic and changing industry."

Discussing the relative importance of producers and consumers Lord Chandos said : "I think we are in some danger of undermining our industrial foundations by disregarding too much the interests of producers—after all the Welfare State depends on them.... We have to be careful that we do not protect the consumer to such an extent that the industry from which he derives his income is made bankrupt by the mere extent of the protection which he is supposed to enjoy.... On broad principles I am in favour of the Restrictive Trade Practices Act, but its extremely stringent application has been one of the causes which has made our particular industry so difficult to run upon sound lines during the last few years. Its timing, also, has coincided with the intense new competition coming from the Continent, from Germany and Switzerland and from Japan. So I make a little plea that the producer should be rather regarded as the principal source of our wealth, someone even to be wooed and not only exhorted and warned—someone even to be cosseted a little."

Referring to the subject of planning, Lord Chandos said that the electrical industry, like a great many others, had to plan on a minimum of about a four years programme. He went on : "Of the total capital investment in the country, 40 per cent is for the Government, Government agencies, nationalised bodies, and so on, and about this investment we know all too little. It is here that business is hoping that the new planning body will be useful in bringing together and publishing the information about the investment plans of these bodies.... In line with this I would guess, but I do not know accurately, that not far off 40 per cent of plant made by the electrical manufacturing industry goes into Government use. Thus, fluctuation in the Government's policy towards capital investment has a direct effect upon about 40 per cent of our industry. Moreover, the vagaries of Purchase Tax and hire purchase affect quite a large part of the remaining 60 per cent, and make it extremely difficult not to interpolate a good deal of guesswork into our plans.... It would, therefore, be a very jaundiced industrialist who did not at least make some genuflection to the new idea of an overall planning body. The greater part of its work should clearly be directed towards forming a longer-term and more stable Government policy, since Government action over its own investment, interest rates and taxation is the key to the steady growth of our economy. This is a matter upon which BEAMA has, to my mind very rightly, directed its attention, and it has made representations to this effect."

Recording Transistor Life Test Data

EQUIPMENT for recording parameter measurements on transistors undergoing extended life tests has been installed at the Manton Lane, Bedford, factory of Texas Instruments Ltd., (THE ENGINEER, July 7, 1961, page 19) by the Electronics Division of Microcell Ltd., a member of B.T.R. Industries Ltd., Herga House, Vincent Square, London, W.C.1. The life tests are conducted on 2000 transistors housed in five temperature-controlled ovens.

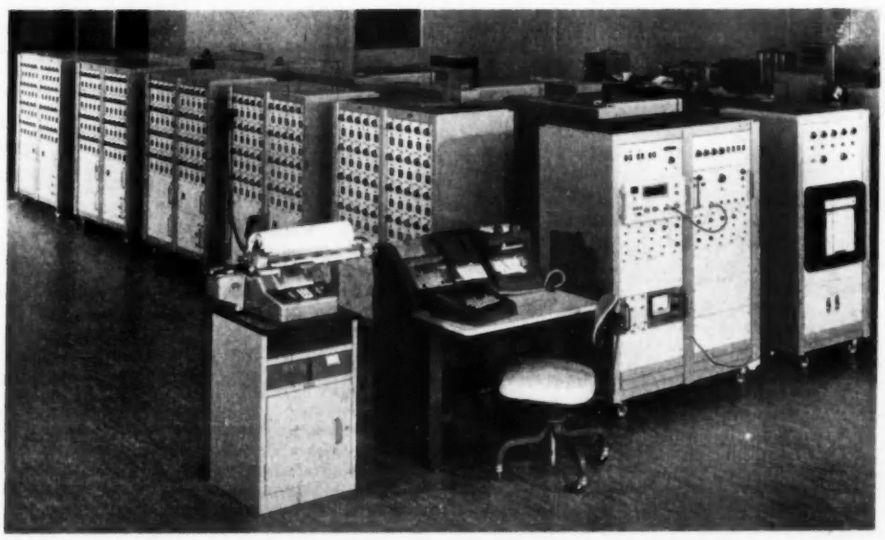
Input leads from the 400 devices in each oven are terminated on forty separate modules in a double-bay distribution rack, each module having a multi-ray switch enabling the ten devices connected to it to be selected in turn. As seen in the accompanying illustration, five double-bay racks are required for the 2000 transistors. The racks were supplied by Linvar Ltd. To make a test, an operator inserts a special plug with pistol grip into the multi-way socket of the appropriate module and selects the device required on the rotary switch, which only releases the selected device from dissipation. The multi-way plug has a flying lead which connects the device to the automatic measuring equipment, and the plug also incorporates interlock wiring, monitor lamp and trigger switch to start the automatic testing equipment.

When the plug is inserted and the first device has been selected, the monitor lamp on the pistol grip will light—provided the data handling equipment is in its start condition ; operation of the trigger switch will then start the automatic testing sequence. The parameter data of each device are recorded on a punched card and also in tabulated form on a typewriter. A separate punched card is used for each device, and the card also records date, time and device number. The date is derived from a date switch, the time from a digital clock and the device number from a discrete coding system within the distribution racks. This block of information is punched out on the card by an I.B.M. punch and typed in tabulated form by an "Addo-X" printing tabulator before any measurements are made. Whilst this punching and typing operation is being carried out, the device selected is still in its life test dissipation condition.

On completion of this part of the record, the device is connected into the first of its parameter test configurations and a digital voltmeter is connected to the required test point. A delay of 100 milliseconds is introduced for the device to settle into its new circuitry, and the digital voltmeter is then given a "digitise" pulse. When the voltmeter has completed its conversion, the digital measurement is read out into the card punch and tabulator. During the time that the punch and typewriter are recording the information, the device is returned to full dissipation conditions. This process is repeated test by test until all the required parameters have been recorded, after which the card punch ejects the card, and the tabulator makes a carriage return and line shift. The monitor lamp on the pistol grip plug now indicates that the data handling equipment can accept a new set of data. The operator selects the next device and the sequence of events is repeated.

The parameter measurement and test configuration units are separate, interchangeable, plug-in modules containing their own constant voltage, and/or constant current generators together with the required number of circuit switching dry reed relays. The majority of measurements made are at d.c. (leakage, current gain, &c.), but some low frequency a.c. measurements are also taken. Manual selection of individual parameter units is provided in the equipment so that initial calibration and setting up of the test configurations can be carried out. Provision of a "local" socket enables devices to be tested automatically at room temperature without dissipation being applied, enabling the equipment to be used as a versatile high-speed transistor test set.

[Reply Card No. 1360]



Data acquisition and printing equipment for transistor life test measurements

SHORTER REPORTS *(Continued)*

Polished Stainless Steel Sheet Protection

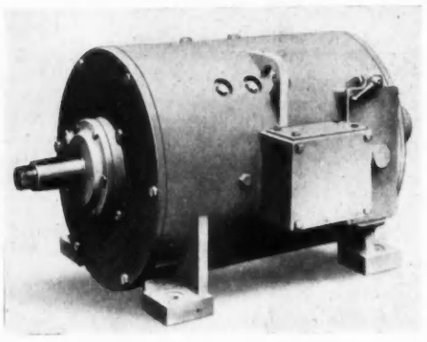
To protect polished stainless steel sheet in transport, storage and initial handling on fabricating lines, Firth Vickers Stainless Steels Ltd., Sheffield, has introduced a protective covering of P.V.C. or latex backed paper and developed a machine for its application. This machine can apply paper with a latex backing and low tack adhesive properties in a single strip on stainless steel sheets up to 48in wide. The same width sheets can be covered with P.V.C. in two strips. The machine has been installed on the inspection conveyor line in the works so that the protection can be given immediately after sheets have been checked and approved.

The firm points out that although the two protective materials provide suitable protection against most forms of damage, there is doubt about their suitability for press work. The best compromise at present is considered to be for protected sheets to be used up to the stage of cut blanks being pressed. The protective tape should be removed at this stage and in subsequent pressing operations there should be used either a loose thin sheet of polythene or some press lubricant to minimise scoring by the press tools. The results from using thin polythene film for this purpose seem to be encouraging and the possibilities are being explored of producing a thin adhesive tape having the protective characteristics of P.V.C. with the greater plasticity of the polythene. Such a tape could then be used both for protection in handling and through pressing operations.

Heavy-Duty Solid-Frame D.C. Motors

A NEW range of heavy-duty d.c. motors has been introduced by Laurence Scott and Electromotors Ltd., 376, Strand, London, W.C.2. These machines are mechanically interchangeable with mill motors built to A.I.S.E. standards but are of solid-frame construction. On drives for which a split-frame is essential the company's ranges of "super-mill" and A.I.S.E. motors are still available. But for many duties which do not justify the extra cost of split-frame motors the new "Dreadnought" range provides a more economical drive.

As can be seen from the accompanying illustration the magnet frame, which is of thick rolled low-carbon steel, occupies the whole length of the machine. The end shields are made of thick flat mild-steel plates, with mild steel webs on the larger machines to give added stiffening. On each side of the machine there is a large rectangular opening with a vertical cover, giving easy access to the brushgear. Two alternatives are available for cable entry : either a projecting terminal box, as illustrated ; or the cable ends can be brought out through glands in the plain cylindrical frame. The brushgear is carried on a cast-steel rocker so that brush changing can be carried out through one opening if the other is inaccessible. The brushgear incorporates "Tensator"-type brush-tensioning assemblies which are designed to give constant brush pressure and performance under conditions of shock and vibration.



Heavy-duty solid-frame "Dreadnought" motor fitted with terminal box ; alternatively the cable ends can be brought out through glands in the cylindrical frame

The armature is built on a spider to allow the shaft to be extracted. Insulation of the armature winding from earth is provided by a laminate of glass, polyester film and mica, lining the slots. Glass tape and polyester enamel are used for the inter-turn insulation of the armature conductors. The wound armature is double-dipped in thermosetting varnish and then baked. The same insulating materials are used on the field coils and the same dipping and baking treatment are given. The shaft is made of 3 per cent nickel steel and at each end there is a tapered extension with keyways, lock-nuts and washers. A fabricated mild-steel cover shrouds the extension that is not in use. Normally inch-size bearings are fitted but metric sizes can be supplied if required.

Ratings of the present range of "Dreadnought" motors are tabulated below :

Frame size	Horsepower output	Speed in revolutions per minute 230V supply	440V supply
1602	7½	800	935
1603	10	725	810
1604	15	650	725
1606	25	575	635
1608	35	525	585
1610	50	500	530
1612	74	475	510
1614	100	460	475
1616	150	450	460
1618	200	410	415

The above figures are for series-wound machines, but the range also includes shunt- and compound-wound machines which can be supplied with speeds up to 5 per cent higher than those tabulated. For the above outputs, the motors are rated as follows : totally enclosed, 1 hour rating with 75 deg. Cent. rise ; forced ventilated, 6 hour rating with 75 deg. Cent. rise.

[Reply Card No. 1348]

Two Engineering Exhibitions

Two exhibitions of interest to engineers and manufacturers are to be held next week—Monday, November 13 to Saturday, November 18 inclusive—at Earls Court in London. Both of these events, the second Engineering Materials and Design Exhibition and the ninth International Factory Equipment Exhibition, have been organised by Industrial and Trade Fairs Ltd., and a conference is to be held in conjunction with each of them.

The Engineering Materials and Design Exhibition, as its name implies, is designed to display the latest components, materials and designs of industrial concerns. At the associated conference, to be opened by Sir William G. Penney, the following papers will be presented for discussion : "Design Problems with Bluebird," by L. H. and K. W. Norris ; "Organisation of a Materials Department," by F. C. Carpenter ; "Metallurgy Applied to the Selection of Materials," by D. Birchon ; "Elastomers in Engineering," by D. A. Smith and D. G. Franks ; "Recent Developments in Insulating Materials," by J. Wainwright ; "Recent Developments in Graphite," by Prof. A. S. Kennedy ; "Adhesives for Engineering," by E. J. Catchpole ; "Designing for Die Castings," by H. K. Barton ; "The Case for Steel Castings," by F. Clymer ; "Investment Castings," by L. S. Taylor, and A. G. Mason ; "Steel for the Design of Low Temperature Equipment," E. Gill ; "Permanent Magnet Materials," J. Gould ; "Sintered Porous Media," by G. Brewer and A. Clayton ; "Sintered Friction Materials," by R. I. Blackwell and J. C. Hewitt ; "Plastics Coatings," by N. Vison ; "Plastics Coated Steel" by F. Smith ; "Composite Structure and Application," by B. Noton ; "Use of Aesthetics in Machine Design," by F. C. Ashford ; "Influence of Corrosion on the Design of Chemical Plant," by E. Warde ; and "Loading Statistics as a Basis of Structural and Mechanical Design," by T. Haas.

Over 350 companies will be showing their products at the International Factory Equipment Exhibition and the exhibits will be grouped in fourteen sections, each corresponding to a major division of industry. Two conferences to be held concurrently with this exhibition have been organised by the British Productivity Council. One of these conferences, to be held on November 13, 14, and 15 will cover "Efficiency in To-day's Factory" ; the other, to be held on November 16, will be on the subject "Producing for European Markets."

Ceramic Triode for R.F. Heating

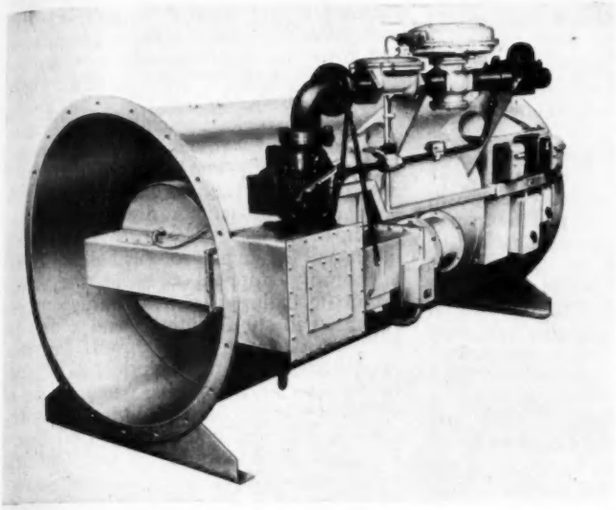
To overcome the limitations on the power output of high-frequency industrial heating valves imposed by glass envelopes, a valve with an all-ceramic envelope has been introduced by Standard Telephones and Cables Ltd., Connaught House, Aldwych, London, W.C.2. This is believed to be the first valve of its kind to be marketed in the United Kingdom. In glass-envelope valves it has been necessary to lower the anode voltage when working at frequencies above 50 Mc/s because the dielectric currents set up at such frequencies may heat the envelope to melting point. The alternative has been to use a special glass, or one with a higher melting point. On the other hand the ceramic material used for the envelope of the new 3RC/223E valve combines low loss factor with high melting point, and the valve may be operated with full rated voltage at frequencies up to 100 Mc/s. The 3RC/223E is a near equivalent to the 3J-Q-R-Z/222E family of valves which operate from a 600V supply and develop up to 24kW of output power. Other improvements in the new valve include a shorter coaxial stem, making for ease of cavity mounting, and an improved cathode with a greater reserve of emission. It is available in forced-air-cooled, vapour-cooled and water-cooled versions.

Power triode with all-ceramic envelope

[Reply Card No. 1346]

Gas-Fired Air Heater

A GAS-FIRED air heater now made by Woods of Colchester Ltd., Colchester, is used in conjunction with an "Aerofoil" fan and is designed to provide a simple and economical means of supplying heated fresh air through ducting for space heating and drying processes. The equipment uses mains gas as the heating medium and is made in a number of sizes with maximum capacities ranging from 163,000 to 1,000,000 B.Th.U. per hour. These heaters were designed in collaboration with the Gas Council, and are



Gas-fired air heater with a maximum capacity of 1,000,000 B.Th.U. per hour

stated to have an efficiency such that between 75 and 80 per cent of the heat input is utilised—depending on the volume of air being handled. In these heaters, one of which we illustrate, the products of combustion are entirely separated and cannot pass into the warmed air supply.

Heaters are made in two designs—a straight-through type giving a high temperature rise in relation to air volume and a by-pass model providing large air movement with moderate temperature rise. For heating and ventilating duties requiring variation in output the burner can be fitted with a modulating valve controlled by thermostat or from a control panel as appropriate. An on/off switch can be fitted to control the burner and main fan for constant duties, and where sustained ventilation is required this switch can control the burner alone, leaving the main fan running. For summer ventilation the fan can, of course, operate alone.

Each heater installation is provided with automatic press-button starting and ignition, which gives efficient control and operation with automatic flame monitoring, and cut-out switches to protect the equipment against failure from any cause.

[Reply Card No. 1330]

High-Power Short-Wave Transmitters

IN addition to the four 250kW short-wave transmitters for the B.B.C. stations at Rampisham and Daventry to which we referred in our September 29, 1961, issue, page 548, six similar transmitters are being supplied by Marconi's Wireless Telegraph Company Ltd., Chelmsford, Essex, for the "Voice of America" relay station at Woofferton. All ten transmitters employ a modulation system designed to overcome the increasing interference on the short-wave broadcast bands by enabling the signal to be modulated to a much higher average than is possible with normal practice. The audio input level to the transmitter is 9dB above that required for 100 per cent modulation, but it is clipped and shaped in the audio circuits to give 95 per cent modulation.

The resultant output from the modulator is consequently no longer of sine wave aspect, but rather a pulse with sloping leading and trailing edges—a wave shape termed "trapezoidal." The modulated carrier envelope is likewise no longer a sine wave. Under these conditions it has been established that the intelligibility of the signal received at a distant point is increased at least 3·5 dB above that produced by sine wave operation at equivalent output power, and is equivalent to the effect obtained by more than doubling the transmitter power. The modulation is continuously variable from sine wave to trapezoidal so that the characteristics of the transmission can be adjusted to the optimum for working through interference of given severity.

Clipping of the audio signal to produce the trapezoidal wave shape can result in effects tending to peak the modulation level beyond 100 per cent, with consequent tripping of the transmitter. To avoid this a phase-correcting network in the sub-modulator introduces intentional distortion which on reaching the modulator output stage is arranged to cancel any actual distortion produced at that point. The power content of the clipped wave is more than one-and-a-half times that of a sine wave of equivalent modulation level, and as a consequence a modulator of increased power handling capacity has to be provided. The main h.t. rectifier (which supplies the main r.f. and modulator stages) must also be capable of delivering more power, for whereas with 100 per cent sine wave operation the audio power delivered to the modulated r.f. stage is 0·5 of the d.c. input to that stage, in the case of 95 per cent trapezoidal modulation the value increases to 0·768. Similarly, whilst the r.f. output with 100 per cent sine wave modulation equals 1·5 times the unmodulated carrier power, the figure for 95 per cent trapezoidal modulation is 1·768.

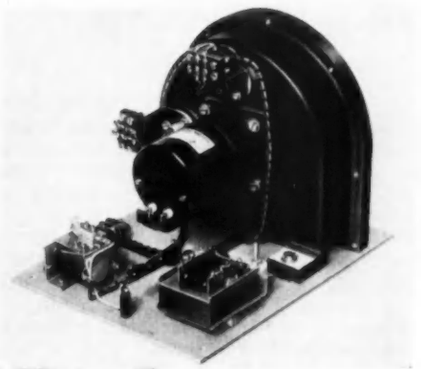
By the use of wideband amplifier techniques, only one of the three r.f. driver stages needs tuning to cover the 3·95–26·1 Mc/s frequency range, and no component changes are required. The penultimate r.f. amplifier and its output transformer are again of wideband design. In the final r.f. amplifier stage and the output coupling unit, tuning is by vacuum variable capacitors. The output coupling unit is inductively coupled to the final stage and uses plug-in coils mounted on a coupling truck. Adjustment of coupling is provided by traversing the truck along rails by means of a motor drive controlled from the transmitter front panel. This operation does not affect the output tuning. The feeders are coupled to the truck by a sliding telescopic coupling which accommodates the truck movement but does not affect the feeder impedance.

Water for vapour-cooled valves in the transmitter is fed from a common high-level tank to the individual jackets, in which the water level is kept constant by means of weirs. Vapour, together with any overspill of water from a weir, is taken through a relatively large-bore pipe which slopes down to a low-level vapour separator tank. The vapour is then taken to a heat exchanger and the resulting condensate is pumped back as water to the high-level tank. The latter has a capacity sufficient to allow the transmitter to operate for seven to ten minutes without the water-pump being in action, thus enabling a pump fault to be detected and the reserve pump to be brought into service without going "off the air." A magnetic valve is installed in the feed from the high-level tank so that the level in the tank is maintained when the transmitter is in the standby condition and the pump inoperative. The methods described enable various valves at differing height levels to be fed from a common header tank, with the further advantage that the level in the individual valve boiler remains constant, whilst the space above the valve can be kept clear, making valve-changing easier.

[Reply Card No. 1347]

Electromechanical Integrator

ADDITION of a shutter and photocell system to a standard d.c. integrating motor of Electro Methods Ltd., Caxton Way, Stevenage, Herts, enables the shaft rotation to be converted into electrical impulses for digital readout or control purposes. We illustrate the assembly, known as the Series 5300 integrator, showing the motor attached to the gearbox and the aluminium alloy casing enclosing the lightweight disc shutter which rotates between a projector lamp and the photocell. Normally the complete unit illustrated



Integrator motor and photocell system for counting or control purposes

is enclosed in a sheet steel dustproof case. A wide range of impulse rates is obtainable by variation of the gearbox ratio, the number of holes in the shutter, and the motor speed. The exciter lamp is a low-voltage, lens-ended lamp of special design which is supplied through a transformer on the baseplate and is run below its rated voltage to prolong life. The photocell is a Ferranti M.S.I.A.E. silicon diode connected directly to the output terminals. In the equipment illustrated a twin photoelectric system is provided, the relay on the baseplate being arranged to energise a standby exciter lamp should the main lamp fail. An additional contact on the relay enables a 240V a.c. alarm circuit to be included. For most applications an impulse amplifier is needed for operating electromagnetic and other counters, and a magnetic amplifier or transistor pre-amplifier may be required to provide sufficient input signal.

[Reply Card No. 1309]

Cleaning Solvent

THERE is now to be manufactured in this country 1·1·1 trichloroethane, a solvent similar to trichlorethylene in its action but devoid of the anaesthetic effects of the established material. It will be made by the General Chemicals Division of Imperial Chemical Industries Ltd. at a plant of Widnes, and marketed under the trade mark "Genklene." It is regarded as especially suitable for cold cleaning, and can be purified by distillation.

[Reply Card No. 1362]

INDUSTRIAL NEWS

Specialist Contractors' Committee

A committee to deal with matters of common interest to industries engaged on specialist engineering work on building and civil engineering projects was set up on November 1. This body, which is the culmination of a number of years of informal co-operation between the founder-members, is called the Committee of Associations of Specialist Engineering Contractors (C.A.S.E.C.). The founder-members are: the Association of Heating, Ventilating and Domestic Engineering Employers; the British Constructional Steelwork Association; and the Electrical Contractors Association (Incorp.). It is hoped that the committee will provide a simple and quick means of consultation with specialist engineering contractors, and serve as a negotiating body on matters of common interest. Membership will be open to any trade association representing specialist engineering contractors engaged on building and civil engineering projects.

Education for Management

At the annual dinner of the Institution of Production Engineers held at the Dorchester Hotel in London last week, Mr. Harold Burke, the president, said that in spite of the strides made in the field of education for management since the end of the war, the United Kingdom was still well behind the major world powers in training sufficient personnel to organise and control industry. An intensified effort was needed in the universities and in the technical colleges to increase the facilities for the study of production engineering and management control, and both industry and the Government, Mr. Burke said, should share the responsibility of providing such additional facilities as were required to permit all universities and colleges to accept a greater number of students.

Mr. Burke went on to suggest that the Government should appoint a leading industrialist as Minister of Production to advise the Cabinet on the country's industrial and economic affairs and, aided by a planning board of industrialists, to take effective action to advise and, if necessary, direct industry. If British Railways considered that it was important that it should have a top-ranking industrialist to direct its organisation, said Mr. Burke, how much more important it was that the whole country should have, at the head of industry, the most talented industrialist it was possible to find.

Public Investment in Great Britain

The White Paper "Public Investment in Great Britain, October 1961" (Cmnd. 1522) states that expenditure on public investment has increased markedly in recent years. Between 1955–56 and 1959–60 it rose from £1275 million to £1620 million. This upward trend eased off in 1960–61, but is expected to be resumed this year and to continue in 1962–63. The grand total of the forecast out-turn for 1961–62 is £1755 million, and the approved expenditure for 1962–63 as at October 1, 1961, was £1840 million. Expenditure on the programmes of the nationalised industries, the public corporations and the Post Office accounts for one-half of all public investment. The electricity programme is the largest (£397 million for 1962–63), followed by those of the British Transport Commission (£177 million) and the Post Office (£118 million). About two-fifths of the total consists of programmes executed by the local authorities. Of these housing is substantially the largest single programme, followed by education, though the aggregate of small programmes is large and growing. The remaining one-tenth of the total is expenditure upon central Government programmes, of which the motorways and trunk road programme is the largest, though, as with local authorities, the aggregate of small programmes is a substantial element in the total. In the majority of programmes the expenditure is expected to be somewhat higher, in real terms, in 1962–63 than in 1961–62. There are increases in the estimated expenditures on the electricity programme, on roads, hospitals, and on the Post Office programme, and despite adjustments which have been made, on education, water and sewerage, and the aggregate of local authority small programmes. Within the total the volume of new construction is expected to increase, with expenditure rising from £955 million in 1961–62 to £1005 million in 1962–63.

Railway Advisory Service

Development of the activities of the United Kingdom Railway Advisory Service of Transport has necessitated the appointment of a full-time chairman as from November 1. The appointment is held by Brigadier A. E. M. Walter, formerly part-time chairman of the service. This section of the Ministry of Transport draws upon the technical resources of the British Transport Commission and British Railways, the British railway equipment industry, and British consulting engineers in providing technical advice and assistance on railway matters to any country on request.

Since the formation of the U.K.R.A.S. senior railway engineers from this country have been sent to India, Pakistan, East Africa, Rhodesia, and Latin America. Training has been arranged in this country for students from India, Pakistan, Sudan, Japan, Rhodesia and Jordan, among many other countries, and lecture tours have been carried out in Argentine, Brazil, Peru and Colombia in 1960, and in East Africa and Rhodesia in 1961. Arrangements are at present in hand for two lecture tours to the Far East covering India, Pakistan, Burma, Thailand, Malaya, Indonesia and Ceylon at the beginning of next year, and for a further lecture tour to South America. A number of technical and economic studies are contemplated or in hand for some half-a-dozen countries, and U.K.R.A.S. is assisting with the provision of candidates for railway appointments with international organisations, notably the United Nations. In addition, consultant services are provided by correspondence to railways throughout the world on all aspects of operation, a regular technical bulletin and a film describing the Service's activities are being planned for international circulation, and a new training brochure is in preparation.

Unemployment

The final unemployment figures for Great Britain for October 16 show little change from the provisional figures reported in our November 3 issue. The total of 365,745 included 45,899 married womem and 4179 school-leavers. The number of persons unemployed for more than eight weeks was 143,906 which was 45 per cent of the wholly unemployed.

During the period September 11 to October 16 unemployment rose in most industries and services. Nearly two-thirds of the overall increase of 24,000 in manufacturing industries was among the temporarily stopped. The principal changes were increases of 12,200 in metal manufacture (including 11,400 temporarily stopped) 6800 in the vehicle group (including 6100 temporarily stopped) and 2200 in ship-building; and a decrease in the textile group of 3600 who had been temporarily stopped. The principal increases in the non-manufacturing sector were of 12,300 in miscellaneous services (including 6900 in catering, hotels, &c.), 7200 in construction, 4300 in transport and communication and 4000 in the distributive trades. There was a reduction of 10,400 in the number of school-leavers registered as unemployed.

The increase between September and October in the numbers wholly unemployed was more than the normal seasonal increase in each of the main groups of industries, other than the catering group. Between September 6 and October 11 there were decreases in the number of unfilled vacancies in almost all industries and services—a reduction of 17,000 in manufacturing industries including decreases of 5400 in engineering and electrical goods, 1700 in metal goods and 1700 in the food, drink and tobacco group.

Family Allowances and National Insurance

Among the provisions in a Family Allowances and National Insurance Bill presented to Parliament by the Minister of Pensions and National Insurance on November 1 are an increase by 15s. a week of supplements paid to certain totally disabled people who, because their accidents occurred or their diseases were contracted before 1948, cannot qualify for benefit under the Industrial Injuries Act. Partially disabled persons on maximum compensation will receive increases of existing supplements, or in some cases a new allowance, of up to 10s. a week, subject to the workmen's compensation loss of earnings rules. There will also be an increase of 7s. 6d. a week in allowances payable under the Industrial Diseases (Benefit) Acts for uncompensated partially disabled men suffering from pneumoconiosis and byssinosis due to pre-1948 employment.

Other provisions include widening the scope of the Industrial Injuries Acts to cover accidents which occur in the course of a person's employment but are not at present covered because they result from "common risks," e.g. assault or "skylarking," attack by an animal or being struck by lightning, and raising of the earnings limit for low wage earners, below which an employer has to bear a larger proportion of the contribution than otherwise, from 60s. to 80s. a week.

PERSONAL AND BUSINESS

Appointments

DURAPIPE AND FITTINGS LTD., has appointed Mr. D. C. B. Chandler as United Kingdom sales manager.

THE TARMAC GROUP OF COMPANIES announces the appointment of Mr. D. G. Sillars as a director of Tarmac Roadstone Ltd.

MR. N. R. D. GURNEY, M.I.E.E., has been appointed general manager of Davy-AEI Automation Ltd. He is also a director of the company.

MR. LESLIE DAVIES has been appointed a director of Pulsometer Pumps Ltd. and has assumed the responsibilities and title of works director.

MR. E. M. BELLAMY, A.R.Ae.S., has joined British Executive and General Aviation Ltd. as technical assistant to Mr. J. W. P. Angell, group production manager.

MR. CYRIL TOYER, A.M.I.Mech.E., A.M.I.Mar.E., has been appointed to the London office staff of Drysdale and Co. Ltd., as marine sales manager (London).

CAPTAIN I. F. M. NEWNHAM, R.N. (Retd.), has joined Short Brothers and Harland Ltd. as manager of the Company's precision engineering division at Castlereagh, Belfast.

DEWHURST AND PARTNER LTD., announces the appointment of Mr. E. Trattles as Western area sales manager. He will operate from 56-58, Barton Street, Gloucester (telephone Gloucester 25613).

BRITISH AIRCRAFT CORPORATION LTD. announces that Mr. Trevor H. Tarr has been appointed sales publicity officer for the aircraft division of English Electric Aviation at Warton airfield in Lancashire.

BRITISH INSULATED CALLENDER'S CABLES LTD. announces that, following the retirement through ill-health of Mr. J. R. Halliday, Mr. John P. Evans has been appointed manager of the market research department.

THE COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH has appointed Dr. John Vernon Dunworth as deputy director, National Physical Laboratory, in succession to Dr. G. Macfarlane, who is shortly to take up the appointment of director of the Royal Radar Establishment, Malvern.

ASSOCIATED ELECTRICAL INDUSTRIES LTD. announces two new appointments in the heavy plant division. Mr. J. A. Garrod, A.M.I.E.E., becomes engineer-in-charge, control equipments, plant applications engineering department, and Mr. G. H. Sutton, Assoc.I.E.E., is appointed commercial engineer-in-charge, rolling mills, large electrical machine sales.

MR. R. L. H. DAMERHAM, technical director of Durapipe and Ftitings Ltd., has been elected chairman of the new Thermoplastic Pipe and Fittings Group of the British Plastics Federation. Initial membership of the Group, which is open to firms engaged directly in the production of thermoplastic pipe or pipe fittings, was stated at the recent inaugural meeting to be twenty.

Mr. A. F. ROGER, chairman of Automatic Telephone and Electric Company Ltd., and Sir Harold A. Wernher, Bt., chairman of Ericsson Telephones Ltd., have been appointed to the board of directors of The Plessey Company Ltd., following the completion of the merger between The Plessey Company Ltd., Automatic Telephone and Electric Company Ltd. and Ericsson Telephones Ltd.

MR. F. BRIAN HOLMES, M.Inst.Gas E., chairman and managing director of W. C. Holmes and Co. Ltd., retired as managing director on October 31. Mr. Holmes will retain his position as chairman of the company, of the holding company, B.H.D. Engineers Ltd., and of those member companies of which he is at present chairman. He is succeeded as managing director by Mr. A. J. M. Henshaw. Dr. W. T. Cosby, M.Inst.F., M.Inst.Gas E., has been appointed to the board of directors.

Business Announcements

BERGEN TEMPERED LTD., a member company of the Tempered Group, has moved to new premises in Sussex Road, Sheffield, 4.

GATE MACHINERY COMPANY LTD., is to hold an exhibition of machine tools from December 11 to 16 at its showrooms, 172-178, Victoria Road, Acton, London, W.3.

GEORGE COHEN SONS AND CO. LTD., has been appointed sole selling agent in the United Kingdom for all measuring equipment of Czechoslovakian manufacture exported to this country. The equipment is being handled by the firm's Engineers' Precision Tools Department now at Bulwer Street, W.12 (this department will shortly be transferred to Sunbeam Road, London, N.W.10).

BRITISH RAILWAYS states that Mr. R. G. Booth, assistant (permanent way) to the chief civil engineer, North Eastern Region, York, retired recently after completing forty-five years railway service.

BLAW KNOX LTD. announces the appointment of Messrs. A. J. Bass, J. G. E. Davies, S. L. Ward, and A. W. Wylde, D.F.C., A.F.M., of the company's Transmission and Radio Towers Division, as divisional directors.

THE NATIONAL UNION OF MANUFACTURERS, 6, Holborn Viaduct, London, E.C.1, is to propose to an extraordinary general meeting of the organisation to be held on November 15, that its name should be changed to The National Association of British Manufacturers.

GEORGE MELLER LTD., of 24, Fitzjohn's Avenue, London, N.W.3, informs us that it has become the sole United Kingdom representative and agent for Corpus Engineering Corporation of Worcoiter, Mass., U.S.A., makers of vertical and horizontal steam turbines from 1 h.p. up to 250 h.p.

THE HARLAND ENGINEERING COMPANY LTD. announces that its Canadian operations, previously in the hands of Bepco Canada Ltd., have been taken over by The Harland Engineering Company of Canada Ltd., with head office in Montreal. Mr. J. A. Cumming has been appointed general manager and director.

THE MONTGOMERIE REID ENGINEERING COMPANY LTD. announces that it has taken over R. H. Corbett and Co. Ltd., Rochester, Kent, and will now manufacture and market the complete range of trucks which the company produced. This includes the "Hydriver," the "Hycaddy," the "Hydrum" and the "Hybin."

THE ENGLISH ELECTRIC COMPANY LTD., English Electric House, Strand, London, W.C.2, announces that it has concluded an agreement with A.S.E.A. (Allmänna Svenska Elektriska Aktiebolaget) of Västeras, Sweden, to cover the exchange of patents and patent rights in the field of high voltage d.c. transmission.

VICKERS-ARMSTRONGS (ENGINEERS) LTD. announces cross-licensing and selling agreements with Racine Hydraulics and Machinery Incorporated, Racine, Wisconsin, U.S.A. Vickers-Armstrongs (Engineers) Ltd., will manufacture Racine hydraulic equipment at its Weymouth works and will distribute it throughout the British Commonwealth and to European countries.

TURNER AND NEWALL LTD., Asbestos House, 77-79, Fountain Street, Manchester, 2, announces the formation, in conjunction with Cement Ltd., of Dublin, of a company to be known as Asbestos Cement Pipes Ltd. The new factory of Asbestos Cement Pipes Ltd. will be on a site adjacent to the works of Cement Ltd. at Drogheda, and building construction will start in the near future.

CHILTON ELECTRIC PRODUCTS LTD., Hungerford, Berks., has announced the signing of an agreement with Westinghouse Electric International Company (Division of Westinghouse Electric Corporation), under which Chilton will be the exclusive manufacturer of Westinghouse moulded case circuit breakers in the United Kingdom, with non-exclusive sales rights for the rest of the world (excepting U.S.A. and Canada). Initially, the circuit breakers will be imported from the U.S.A. and modified at the Chilton factory, until full-scale production begins.

Contracts

THE CEMENTATION COMPANY LTD. has received a contract amounting to £226,796 for the construction of two bridges on the route of the Darlington By-pass. The bridges are over the river Tees, north of Cleasby, and over the Darlington-Barnard Castle railway line, near the village of Archdeacon Newton in Durham, and work on them is to be carried out in advance of the roadworks. Both bridges have been designed for the Ministry of Transport under the supervision of Durham County Surveyor, Mr. W. H. B. Cotton.

D. NAPIER AND SON LTD. has received an order worth approximately £750,000 for sixteen turbo-charged "Deltic" two-stroke diesels of 3100 h.p. each for use in a further eight "Nasty" class patrol boats to be built for the Royal Norwegian Navy by A/S Westermoen of Mandal, a subsidiary of the design organisation, Boat Services Ltd., Oslo. The existing twelve vessels are regarded as the fastest naval vessels now in operation, with a speed exceeding 45 knots, and can maintain 40 knots for 400 miles. A speed of 35 knots has been sustained heading into a Force 7 gale. These vessels have been armed with, in addition to the four torpedos, either automatic guns or Nord S.S.11 wire-guided missiles.

DUNCAN LOGAN LTD. has received a contract from Lanark County Council, as agents for the Secretary of State for Scotland, for the improvement of about 5¼ miles of the Edinburgh-Glasgow trunk road (A.8), between Newhouse and Baillieston in Lanarkshire. This is the first of a series of schemes to be authorised which will provide a dual-carriageway route between the two cities. The scheme provides for the construction of dual 24ft carriageways, with three grade-separated junctions; it is estimated to cost £1,070,000 and is expected to take about two years to complete.

Miscellaneous

GLASS FIBRE CHUTE.—Thomas Robinson and Son Ltd., Rochdale, are manufacturing a new glass fibre sack chute which is lighter in weight than a metal chute and so reduces the load on the building while being easier to erect. It has an overall diameter of 5ft and is designed in sections 10 $\frac{1}{16}$ in deep, there being eight sections to a pitch of 6ft 10½in. The sections are bolted together at four points and are rigidly held by a 4½in centre column fixed to a cast iron base.

Awards

The British Institution of Radio Engineers has announced the following premiums and awards to authors of outstanding papers published in the Institution's journal during 1960:

The Clerk Maxwell Premium (value 30 guineas): "A Proposed Space-Charge-Limited Dielectric Triode," by G. T. Wright, Ph.D.

The Heinrich Hertz Premium (value 20 guineas): "Features of Cylindrical Waveguides containing Gyromagnetic Media," by R. A. Waldron, M.A. (Associate Member).

The A. F. Bulgin Premium (value 15 guineas): "Reflection Coefficient Curves of Compensated Discontinuities on Coaxial Lines and the Determination of the Optimum Dimensions," by A. Kraus, Dr. Ing.

The Arthur Gay Premium (value 10 guineas): "The Application of Printed Wiring to Development and Small Batch Production with particular Reference to Television Equipment," by E. Davies.

The Leslie McMichael Premium (value 10 guineas): "Microwave Valves: A Survey of Evolution, Principles of Operation and Basic Characteristics," by C. H. Dix, B.Sc., and W. E. Willshaw, M.B.E., M.Sc.Tech.

The Lord Rutherford Award (value 15 guineas): "Energy Stabilisation of a 4MeV Electrostatic Accelerator using Controlled Corona Discharge," by E. C. Fellows (Associate Member).

The Charles Babbage Award (value 15 guineas): "A Computer Storage Matrix Using Ferromagnetic Thin Films," by E. M. Bradley, B.Sc.

Deaths

WE regret to record the death on October 31, at the age of forty-seven, of Mr. J. P. Gregory, B.Sc.(Eng.), A.M.I.E.E., Assistant Manager at Rugby of the Control Gear Engineering Department, A.E.I. Motor and Control Gear Division. Mr. Gregory joined the Control Gear Engineering Department of the British Thomson Houston Company Ltd., on completion of a student apprenticeship and he specialised on industrial contactor control. He was appointed Assistant Manager, Rugby, Control Gear Engineering Department, A.E.I. Motor and Control Gear Division in 1959. For a number of years Mr. Gregory has been a BEAMA representative on several of the B.S.I. Crane Committees.

COLONEL R. T. HARTMANN.—It is with regret that we note the death of Colonel R. T. Hartmann, M.A., F.R.S.A., managing director of Materials Handling Equipment (G.B.) Ltd., on Sunday, October 15. Colonel Hartmann was the founder of I.T.D. Ltd., (manufacturers of "Stacatrucs"), which was later taken over by The Austin Motor Company and Crompton Parkinson Ltd. In 1952 he established M.H.E. (G.B.) Ltd., which is now a member of the Hunslet Group of Companies, and he was for some years sales and executive director of British Straddle Carrier Company Ltd., then in the Fison Group of Companies. Colonel Hartmann was educated at Marlborough and Emmanuel College Cambridge. He served in the Royal Fusiliers, City of London Regiment during the first World War and in the second World War he served with the Royal Artillery and afterwards with S.H.A.E.F. 21st Army Group.

CONTINENTAL AFFAIRS

by Our Continental Editor

Jauntal Bridge

Scheduled for completion before the end of this year, the Jauntal railway bridge in Carinthia constitutes one of the two major bridges which at present are being built in Austria. It crosses the river Drau in five continuous spans totalling 428m, at a height of about 90m above the valley. The superstructure, which carries a single track, has an inverted trapezoidal box section. A hydraulic system anchors the bridge at its ends in such a way that it can expand and contract freely, while in either direction one-half of the braking force is transmitted to each abutment.

IN the course of improving communications in south-eastern Carinthia the Austrian Federal Railways are building a 19km long single-track line between St. Paul and Bleiburg. It will be of great local importance as connections between the Lavant valley and other parts of the country will be shortened by up to 200km. This improvement entails however the construction of two major engineering projects, namely, the approximately 1430m long Langenberg Tunnel and a viaduct across the valley of the river Drau. The latter, known as the Jauntal Bridge, is a structure comprising five continuous spans of a total length of 428·26m which rest on four intermediate piers.

The two end spans have a length of 78·66m, the intermediate spans are 87·4m long and the central span has a length of 96·14m. The piers are tapering rectangular columns of reinforced concrete. The two middle ones rise to a height of 97·9m above their foundations, and the height of the track above the river is 86·4m. The end piers rise to heights of 54·5m and 60·5m respectively above the slopes of the hillside. Its smooth lines and great height gives the bridge a lofty appearance which blends well with the surrounding scenery.

In Fig. 1 we illustrate the cross-section of the superstructure. Since the bridge is intended to carry only a single track the deck could be kept to a minimum in width. As an economic design, a box-section girder suggested itself, but in order to achieve increased torsional stiffness at little extra cost in the amount of steel, the section was made trapezoidal in shape. It widens towards the bottom, which is unusual. The reason for this configuration is that it approximates the shape of a triangle which is inherently stiff, unlike a rectangle which may be deformed into an asymmetric parallelogram.

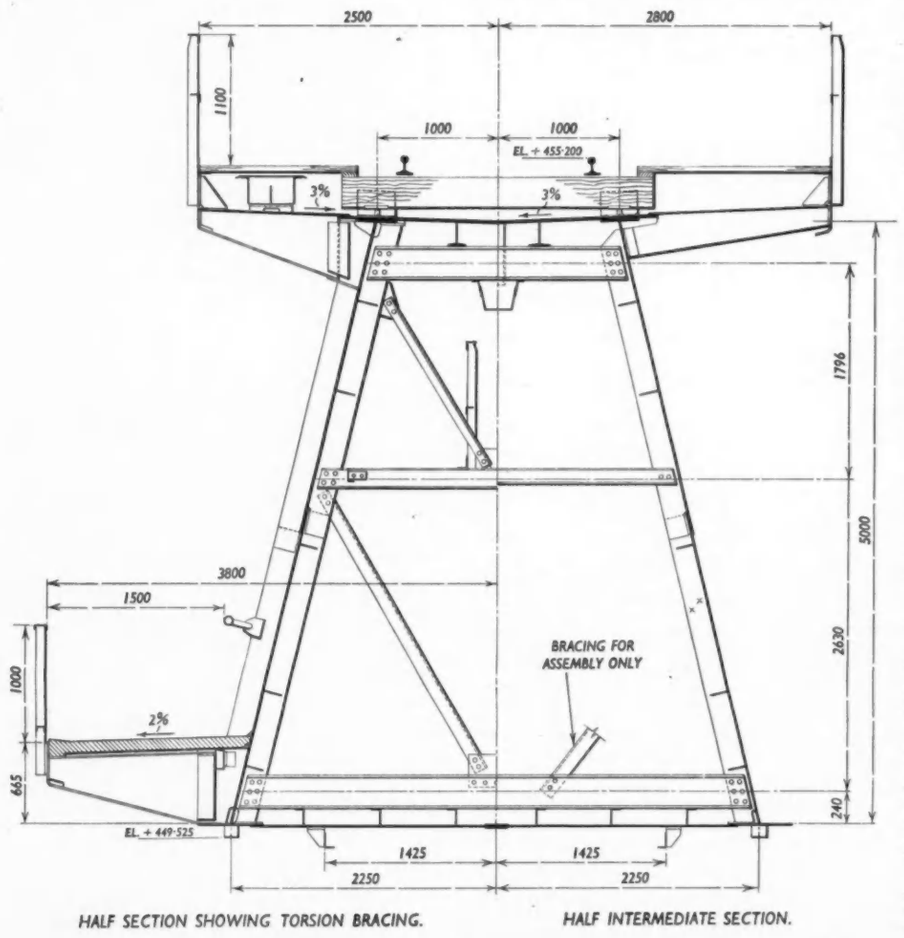


Fig. 1—Cross sections of Jauntal bridge

The whole of the bridge is built up of identical prefabricated elements. As the left-hand half of Fig. 1 shows, these are internally stiffened in two transverse planes, as well as externally by welded-on ribs. The flanges, deck and bottom plates are stiffened internally by longitudinal welded-on angles. The section is 5m high (about 5·5m from the top of the rails to the bottom flange); it is 2m wide at the top, and 4·5m at the bottom. A 1·5m wide footpath cantilevers near the bottom of one of the flanges, while near the top are cantilevered catwalks on both sides, with a cable duct under one. Under the centre of the deck, which slopes inwards, is a gutter for draining the rainwater. Provision has also been made for installing masts for overhead conductor wires, should it be decided later on to electrify the line which at first is to be operated with diesel locomotives. The total steel weight of the superstructure is 1650 tonnes, or about 3850 kg per metre. To this must be added 98 tonnes for supports, railings, and cable ducts.

The sections comprising the superstructure were built by the two principal contractors in their respective works, each section before it was sent out being assembled with the succeeding one, in order to line up the joints correctly. For transport by rail, individual sections were subdivided horizontally into two halves which were assembled at the site. Joints produced in the works are welded, those made at the site are rivetted. The bridge was assembled in two equal portions, one at each end, the two halves being winched towards the middle. During this launching operation the structure rested on a system of rollers placed on the abutments and piers. As may be seen from Fig. 2 the rollers were arranged underneath the flange plates on either side, the edges of the bottom plate being strengthened by heavy square section rails. In order to spread the load evenly over all the rollers at each support, they were supported in a system of balance beams.

A matter of considerable interest is the manner of anchoring the bridge as large braking forces may have to be transmitted to the foundations, and at the same time adequate thermal expansion and contraction must be possible. Assuming a coefficient of friction of 0·125, the longitudinal forces due to a freight train braking or accelerating were specified as 360 tonnes. At the same time, allowance had to be made for the temperature fluctuating over a range of 70 deg. Cent., which implies a variation in length of the order of 1mm per metre. The inconvenience of having to accommodate the resulting total movement of the track is alleviated if the bridge is anchored not at one of the abutments but at or near the centre, at one or several piers. This, of course, means that very heavy horizontal loads have to be transmitted through the slender piers, involving the need for additional reinforcements and stronger foundations.

Initially it had been the intention to anchor the Jauntal Bridge on the two central piers which under a thrust of 360 tonnes would have been deflected by about ±100mm. This deflection would have to be accommodated at the

ends in addition to a thermal expansion of ±90mm. It was therefore considered desirable to fix the bridge at the ends and fit roller supports at the piers. A special hydraulic anchorage permits the bridge to expand or contract as a whole, the total movement being equally shared between both ends while resisting longitudinal forces by setting up reactions which also are the same at both ends. The principle may be gathered from Fig. 3. At each end the bridge is

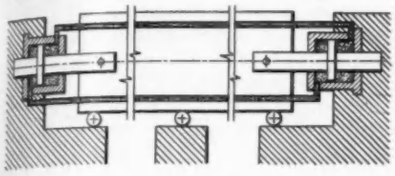


Fig. 2—Principle of hydraulic anchorage at abutments

attached to a piston moving inside an oil cylinder rigidly connected to the abutments by means of high tensile bolts. The inner oil space at one end is connected by a pipe to the outer oil space at the other end, and vice versa. In this way longitudinal forces acting in either direction are resisted, while expansion movement is not. Such a hydraulic system should of course be able to work unattended and with a minimum of maintenance. For that reason no cocks, accumulators, &c., are incorporated. If these cylinders and pipes are completely filled and sealed at −25 deg. Cent. the system may be expected to function satisfactorily over the whole range of temperatures which are likely to be experienced. However, it has been estimated that at +45 deg. Cent. a pressure of 800 atmospheres would be set up by the expansion of the oil, to which a further 200 atmospheres would have to be added arising from the braking effort. It is not yet certain whether these comparatively high pressures will be accepted or whether some pressure relief will be incorporated. On account of the novelty of the hydraulic abutments, the bridge piers have been designed so as to be able to transmit the whole of the braking force by themselves if necessary. The full economic advantages of the design will therefore not be realised on this occasion.

The Jauntal Bridge is being constructed by Waagner-Biró A.G., Vienna-Graz, and Vöest Vereinigte Osterrechische Eisen- und Stahlwerke, Linz.

Climatic Testing Installation

The article describes a recently inaugurated climatic testing station for railway vehicles at Vienna which permits the testing of all kinds of rolling stock—as well as road vehicles and equipment—at ambient temperatures from −40 deg. to +50 deg. Cent. and wind velocities up to 120 km.p.h.

IN 1955, the International Union of Railways (U.I.C.) set up a special commission at the ORE research and testing station in Utrecht to deal with questions of heating, ventilation, and air-conditioning of passenger rolling stock. It is one of the basic difficulties in this field, when evaluating new equipment, that the climatic conditions required for obtaining adequate test results are seldom available in practice. Heating plant designed to cope with outside temperatures of −30 deg. to +10 deg. Cent., and air-conditioning plant of which the chief benefit is experienced in hot weather at +20 deg. to +40 deg. Cent., must be tested at those ambient temperatures which, however, are only exceptionally met with in nature. One of the first tasks of the committee was to carry out test journeys in regions of the Alps and Pyrenees which are noted for their low temperatures, but these trials once again proved the unsatisfactory nature of such an approach.

The proposal was therefore put forward to set up a research station at which any desired test temperature could be realised under laboratory conditions.

Later, the decision was taken to establish the station at Vienna, where a site was made available within the grounds of the Arsenal Governmental testing and research laboratories to which it was to be attached. The institute was financed by nine European railway administrations, including British Railways, the German and International Sleeping Car Companies, and the Austrian Government.

Work began on September 18, 1958, and the official inauguration took place on June 22 of this year.

The installation comprises two separate chambers, one of which is for tests at standstill, the other for tests in which running conditions can be simulated by a wind tunnel. Two additional tracks are available for parking rolling stock while instrumentation is being installed, or alterations are carried out. All test beds are sufficiently long to take even the largest vehicles.

Fig. 1 illustrates the interior of a passenger coach on the test bed.

While it is principally passenger carriages which are to be tested, the equipment can be used in connection with other rolling stock—as exemplified in Fig—2 as well as road vehicles. For instance, it is possible to test the performance of refrigerated wagons, the starting of diesel locomotives and railcars in extreme cold, their behaviour under load at low speeds and high ambient temperatures and the correct functioning of electrical locomotives in extreme

Fig. 1—Interior of DP passenger coach equipped for heating and ventilation measurements in the static test chamber

conditions of temperature or humidity. Among a wide variety of other work which is envisaged is the testing of welded track, and of drive mechanisms and heaters for points at very low temperatures, the frost resistance of concrete sleepers, track movements at extreme temperatures, and the testing of items of equipment.

In the chamber for stationary tests, work is carried out regarding reliability at temperatures below the freezing point, heat losses through the carriage walls, the time and energy required to warm up a carriage or pre-cool it, temperature changes in the water cisterns of carriages parked in sidings, and the reliability and adequacy of heating and air conditioning plant under extreme conditions.

Tests can be conducted over a temperature range of −40 deg. to +50 deg. Cent., and the relative humidity can be set at any desired value. Arctic, tropical, or desert conditions can thus be imitated, including fog, snow, and hoar-frost. In order to achieve all this, machinery with a capacity of 600kW has been installed.

The wind tunnel chamber can be subjected to the same range of conditions, but in addition a 400kW fan makes it possible to reach a wind velocity of 120 km.p.h. At this velocity temperatures of −15 deg. Cent. can be realised; at lesser air speeds the temperatures can be even lower. Special radiant heaters are installed to give the effect of solar radiation.

Besides a steam supply for steam radiators, a

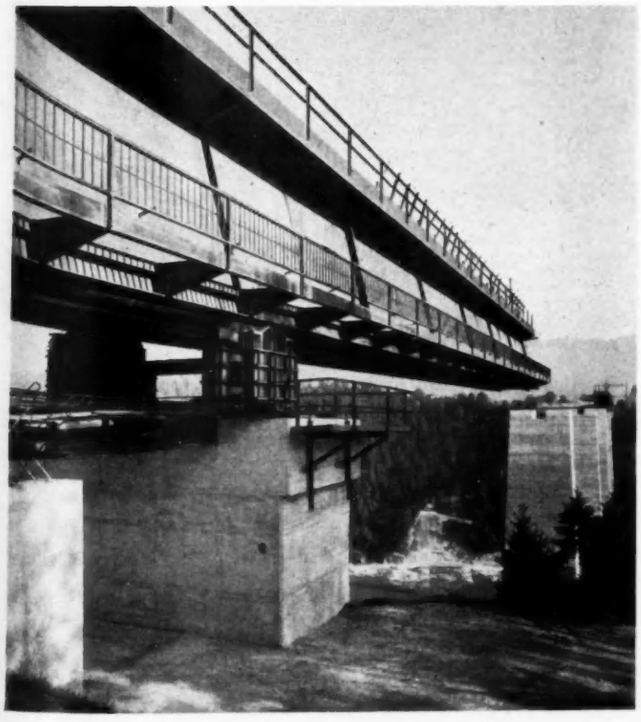


Fig. 3—The two halves of the bridge are being assembled section by section and launched towards the middle (September, 1961). Our illustration shows the support rollers and block and tackle used in the launching

CONTINENTAL AFFAIRS *(Continued)*

Fig. 2—Electric railcar under test in climatic chamber

Fig. 2—Interior of bridge showing hopper linked to crane and discharging on to one of the main conveyors

variety of electric supplies are available corresponding to those in use at the present time, and comprising 16⅔ and 50 c/s at 1000V, 50 c/s and direct current at 1500V, and direct current at 3000V. It has also been necessary to provide means to vary these supply voltages over the range over which they are legally permitted to fluctuate in practice.

Temperatures, wind velocities, relative moisture content, and energy consumption are electrically recorded in a separate room. Instead of using multipoint recorders, it is possible to integrate the readings so as to directly obtain an average value. This saves time, enabling the evaluation of the test to be completed by the time a carriage leaves the test bed. A combined two-way wireless telephone and alarm installation facilitates keeping in touch with technicians working inside the chamber or inside the carriages, and at the same time protects installation and personnel.

Ore Handling Bridge

The Rhine port of Schwelgern has undergone considerable re-development in recent years and the Nuremberg works of M.A.N. have supplied an ore handling bridge with the remarkable span of 85·75m and an overall length of 162m.

Mounting a 16-ton travelling grabbing crane with a radius of 15·5m and fitted with belt conveyors and surge hoppers it is one of the biggest bulk handling installations in use at present.

The bridge, which is shown in Fig. 1, can be slewed by moving each leg 20m to the left or right from its square position. This affords ample freedom in varying the discharge point without moving the ship, an advantage that is important especially where ores of different grades are to be stockpiled separately.

Slewing is made possible by connecting the bridge girder to the land-side support with a pivot bearing, while the support at the water-side is provided with both a pivot and sliding bearing. The pivots take the form of unit columns which M.A.N. has developed primarily for wharf cranes to connect the portal with the revolving superstructure, a design that has been supplied to most European ports and also to overseas ports.

The conveyor system installed in the bridge permits unloading, stockpiling and reclaiming of the ore without it being necessary to move the slewing crane on the bridge. There is a travelling surge hopper of about 22 cubic metres capacity lined with cast basalt, two fixed conveyors and one shuttle conveyor. The system is rated to handle 400 tonnes of ore per hour.

Ore is unloaded by the crane which discharges its grab into the surge hopper. This is coupled to the crane by tie rods of such length that the hopper is hauled along at a distance equal to the crane radius. As a result, the discharging cycle includes only lifting and slewing.

The ore is withdrawn from the hopper by an apron feeder discharging ore to one or other of the fixed conveyors (Fig. 2). These conveyors, one 70m between pulley centres, the other 45m, take the ore from the ends to roughly the centre of the bridge where it is transferred to a shuttle conveyor below. The shuttle conveyor which is 68m long discharges the ore into a hopper with a telescopic chute to deposit it with a minimum of dust formation on the yard or in wagons which take the ore to the blast furnaces.

Fig. 1—Ore handling bridge at the Rhine port of Schwelgern. The bridge is 162m long with a central span of 85·75m and can handle 400 tonnes of ore per hour

Société Louis Breguet

This year the Société Anonyme des Ateliers d'Aviation Louis Breguet celebrates its jubilee. When Louis Breguet founded the company in July, 1911, he already had behind him six years of experience in aeronautical design. With the encouragement of Professor Charles Richet, Breguet at first applied himself to the construction of rotary wing aircraft. On August 24, 1907, the " Gyroplane 01 " powered by a 50 h.p. engine achieved the first manned helicopter flight, with an all-up weight of 578 kg. In 1911, with an aircraft of his own design, Louis Breguet established the 100km speed record at an average speed of 46·6 knots. Among later achievements may be mentioned the closed circuit distance record of 4989 miles, set up in 1925 by Costes and Codos in a Breguet " Point d'Interrogation," while four years later Costes and Bellonte in the same aircraft carried out the first flight from Paris to New York. In 1958, a Breguet 1001 " Taon " for the first time averaged 580 knots (over 1000km/hr) over 1000km.

Present activities include the production of the " Alizé " and " Atlantic " naval aircraft and the development of the blown-wing S.T.O.L. aircraft Breguet 941, 942, and 945. To-day, the company employs 4500 persons. Its roofed-in floor space, at Vélizy-Villacoublay, Toulouse and Biarritz, has doubled since 1956 and now exceeds 1·6 million square feet.

Milan Underground

The first line of the Milan Underground, now under construction, is expected to carry a traffic of 100 million passengers per year, equal to a daily average of about 275,000 passengers, it is stated. The figures of 20,000 per day for Line 1, and 50,000 per day for Lines 1 and 2 together, which were mentioned in our article of October 6, are incorrect.

THE AMERICAN SCENE

By Our American Editor

Free Radicals Research at the National Bureau of Standards

A three-year programme of research on free radicals at the National Bureau of Standards has resulted in a greater understanding of the production and nature of short-lived atomic and molecular fragments. This basic research has also opened the way to several new areas by providing fundamental data on low-temperature phenomena and chemical reactions and by illustrating the effectiveness of advanced experimental techniques.

THE National Bureau of Standards, Washington, D.C., recently completed a three-year experimental and theoretical study on free radicals, sponsored by the U.S. Department of Defence. Scientists from industry joined with the N.B.S. staff in this programme to investigate short-lived atomic and molecular fragments. This centralised research activity not only revealed much about the production and nature of radicals, but also paved the way for research in several new areas, including low-temperature chemistry and the photo-chemistry of solids Other important results of the programme are a better understanding of low-temperature phenomena, improvements in low-temperature techniques, and advances in spectroscopic instrumentation and in X-ray and electron diffraction techniques.

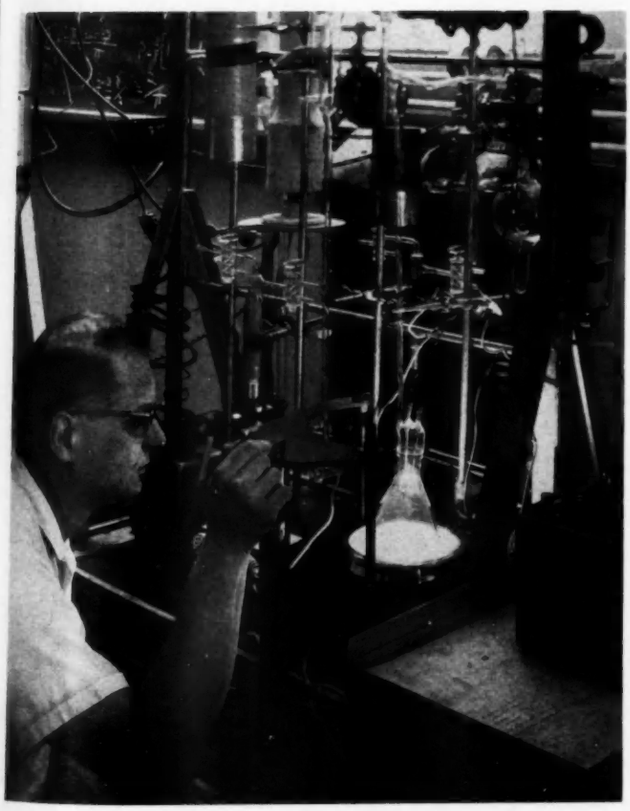
Although free radicals have been known to exist for over fifty years, only recently has research interest been focused on their stabilisation. Stabilised radicals can either be produced in a gas, which is then deposited as a condensed solid on a cold surface, or they can be produced, after deposition, in the condensed solid itself. In either case the excited species are frozen into immobility and sometimes display unusual phenomena, such as bright glows, "flames," and flashes of light. When warmed up, they recombine, actively releasing stored energy.

It was the hope of trapping radicals in large quantities and storing them as a potential source of energy that sparked the request for the Bureau to undertake a comprehensive research programme. However, from the start, emphasis was placed on obtaining basic data and exploring various means of radical production rather than on solving a specific developmental problem. This basic research approach has made the programme an outstanding scientific contribution in spite of the finding that radical concentrations sufficient for practical use probably cannot be obtained.

Production of Free Radicals

Of the several methods available for generating and trapping free radicals, the one most extensively used at the Bureau was an original high-temperature discharge, low-temperature collection technique developed by H. P. Broida and J. R. Pellam. In this method, gases are passed through a high-frequency microwave discharge at 2450 mc/s and then frozen at a temperature of 4·2 deg. K. The concentration of atoms and radicals produced in this way has been found to be relatively independent of the power applied to the resonator. In nitrogen, for example, magnetic susceptibility and electron spin resonance measurements indicate that the nitrogen atom concentration is about 0·1 per cent. at 4 deg. K. When the concentration of atoms exceeds this value of one part in 1000, the solid becomes unstable and explosions are caused by the recombination of atoms.

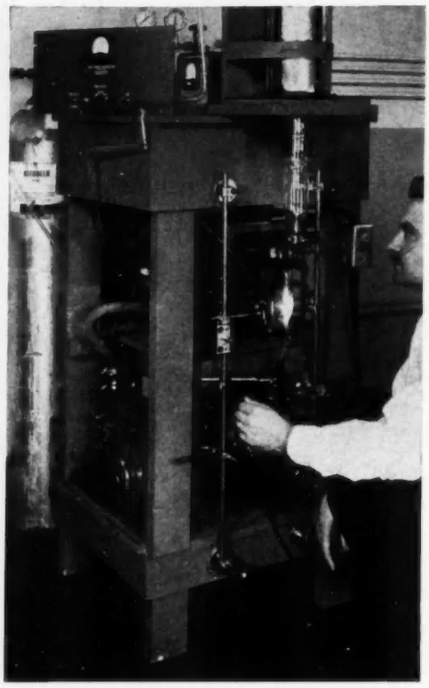
In another attempt at generating radicals in a gas, thermal dissociation was employed. One system has been used to study solids containing unstable molecular fragments. Also employed was another system, in which hydrogen atoms, produced on a hot tungsten surface, diffuse into and react with cold solids to produce radicals. Although it is possible to produce free radicals in a gas by photolysis (ultraviolet irradiation) or radiolysis (X- or gamma-irradiation), these



Production of free radicals by bombarding a solid with hydrogen atoms

Use of the electron bombardment technique for generating free radicals

THE AMERICAN SCENE *(Continued)*



Generation of free radicals by the electric discharge technique, with the radicals becoming trapped on a cold surface

techniques were given no serious study. On the other hand, gamma-ray radiolysis of the solid condensed from the gas has been found to be a highly successful method of radical production, and the N.B.S. has employed electron bombardment extensively with results similar to those obtained in the gaseous discharge method. The concentrations obtained by exposing condensed solids to ionising radiations rarely exceed one part in 1000.

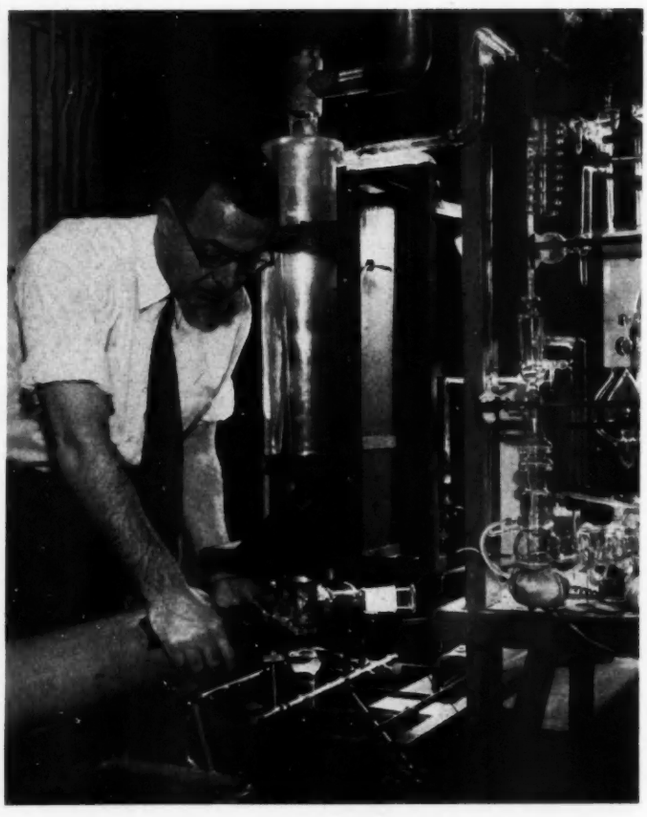
A fairly large amount of work on the mechanisms of radical production has been based on studies of free radical spectra. Even before the Free Radicals Research Programme was initiated, a semi-quantitative interpretation of some spectroscopic features of the very complex light emission from nitrogen deposits was given by C. M. Herzfeld and H. P. Broida. It was suggested that, in the deposition of nitrogen passed through an electric discharge, N atoms are deposited, radiate, and then recombine to form excited N_2 molecules which also radiate. Some atomic features (alpha lines) were attributed to a forbidden transition in N atoms ; other atomic features (beta lines) were ascribed to transition between levels in O atoms ; and the molecular features (bands) were assigned to a transition of the newly-formed N_2 molecules.

It is now clear that the alpha lines do indeed arise from the transition proposed, although the situation is known to be vastly more complex than it was thought at first. The beta lines belong to transitions of O atoms and the bands to transitions of molecules. H. Goldberg and C. M. Herzfeld applied a crystal field analysis to the transition postulated for the beta atomic features, and have found reasonable agreement between experiment and theory. Recently V. Griffing investigated the alpha lines from a different point of view, assuming that an N atom replaces an N_2 molecule in the crystal lattice, and then moves to readjust the lattice to minimise its energy. Several non-equivalent motions of this type can be found, which give rise to enough levels to explain the line group in question. So far the results obtained are only qualitative, but the approach is a very promising one.

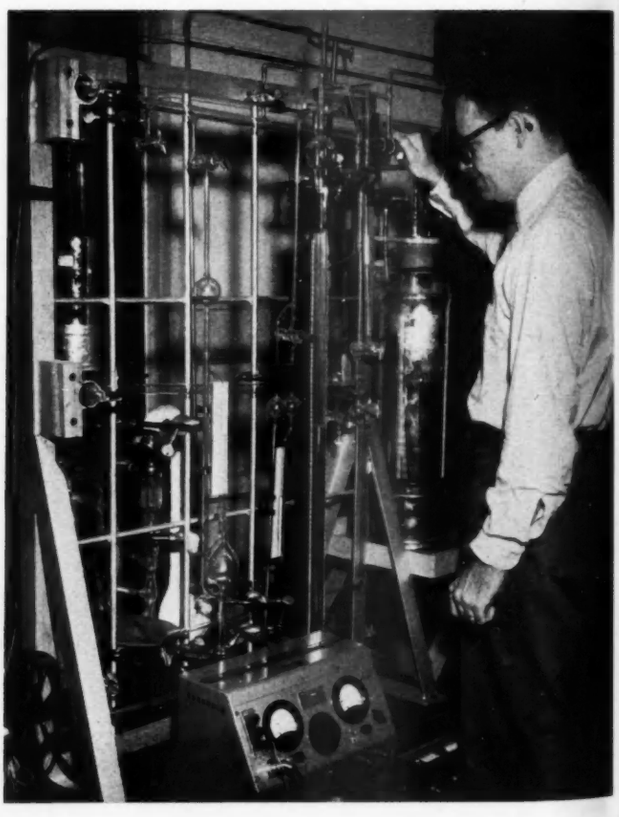
Radical Deposition and Trapping

The condensation of a gas upon a cold surface is one of the least understood of the processes that occur during stabilisation of radicals initially produced in the gas phase. When a molecule strikes a surface, it may rebound back into the gas after a single collision with the surface, it may become bound to a surface molecule for a time before it escapes back into the gas, or it may migrate at random over the surface and coalesce in a process of nucleation with other such particles and thus become a permanent part of the deposit. Measurements of the condensation of argon on a 4 deg. K. argon surface indicated that six out of ten atoms condensed, while it was also found that the condensation of iodine on a 77 deg. K. glass surface occurred with nearly perfect efficiency. It is seen, therefore, that in addition to surface temperature, the material being deposited and the nature of the surface are of significance. In any case, a complete understanding of the stabilisation of gaseous radicals in the solid state must be preceded by a more detailed insight into the deposition process. Although little experimental effort has been expended in this direction, a major part of the theoretical work has been devoted to explaining the mechanisms of radical deposition.

Several theories have been constructed to deal with the deposition problem. Two of these are statistical and study the number of ways in which radicals, molecules, and inert species can be laid down together. This approach, which employs various assumptions about the system, allows the upper limits of radical concentrations to be estimated. One such theory was developed by J. L. Jackson and E. W. Montroll, who considered that radicals form chains. They studied three cases in detail : the deposition of radical chains, the deposition of linear chains containing radicals and molecules randomly distributed, and three-dimensional condensates obtained from a gas containing radicals only and



Spectroscope studies of luminescence initiated in low-temperature condensates by photolysis or electron bombardment



Use of a calorimeter to measure the heat energy produced by the recombination of frozen free radicals

from a gas containing radicals and molecules. A second statistical theory was constructed by S. Golden, who postulated five three-dimensional condensation models: A densely packed model in which all sites in the solid are filled by a radical or a molecule; a diffusely packed model in which all species condense one to a site and then recombine where possible; a surface model in which each condensed layer comes to a stable state before the next layer is deposited; a non-ideal model in which species may evaporate from a surface; and a clustering model which assumes that clusters form in the gas and are deposited as such.

Although the statistical theories have the advantage of being logically straightforward, they ignore energy considerations and diffusion and are, therefore, likely to give high estimates of trapped radical concentrations. An attempt to approach the problem by studying the detailed mechanisms involved in deposition was made by R. Zwanzig, who calculated the probability of the adsorption of an atom on a solid. This theory, constructed for the simplest or radical chain model, can be used to predict mass effects and in certain cases relative deposition rates.

Important contributions on the structure of condensed gases at 4 deg., 20 deg., and 77 deg. K. (the temperatures produced by liquid helium, liquid hydrogen, and liquid nitrogen, respectively) have been made by the N.B.S. X-ray diffraction group. The possibility of obtaining information about the number and type of crystallographic sites available for free radical trapping is an attractive feature of this type of investigation. The materials that have been studied in some detail are argon, nitrogen, oxygen, water, ammonia, diborane, hydrazoic acid, and various alcohols. It was found that, in general, slow rates of gaseous deposition result in solids with a considerably less ordered structure than that obtained with rapid deposition rates. The use of an electric discharge in the gas prior to deposition increases order in solids, and heating amorphous solids causes an annealing to the stable crystalline configuration. Part of the released energy observed in the warm-up of excited solids must be attributed to these crystallographic changes. Some interesting results were obtained also in an electron diffraction study of thin solid nitrogen films at 4 deg. K. and 20 deg. K. For extremely thin films at 4 deg. K., the observed diffraction patterns indicate the presence of randomly oriented fine crystallites. As the amount of deposited material is increased, larger crystals are formed.

A number of significant facts about trapping forces have been discovered through spectroscopic studies. It has become fairly clear that the trapping of atoms in molecular lattices is a complicated phenomenon. For example, in the cases of N trapped in N_2 and O trapped in O_2, loose complex formation with molecules occurs. Both theoretical and experimental evidence lead to this conclusion. Trapping forces have also been investigated in an attempt to discover the existence of positions in or on an N_2 lattice where an N_2 molecule could rotate, either freely or in a hindered manner. The investigators calculated the energy levels of molecules on the surface of the crystal, and also studied the long-range interaction potential between N and N_2.

Characterisation of Stabilised Radicals

Once it has been established that radicals are present in a cold solid, the first question to arise is that of concentration stability. The Bureau has performed several experiments which yielded information on this point. For example, electron spin resonance spectrometer measurements on nitrogen atoms generated in solid nitrogen by gamma-irradiation showed no decrease in signal strength after the solid had been stored at 4 deg. K. for 20 hours. On the other hand, a similar investigation on hydrogen showed a 50 per cent decrease in concentration.

Trapped radicals disappear by at least two distinct mechanisms. One type of flash seems to propagate so rapidly that it appears to cover an area of several square millimetres instantaneously. A second type of flash—called a "cold frame"—propagates so slowly that the movement of a definite front can be discerned. Recent thermal and magnetic studies indicate that these flashes are intimately connected with some critical concentration of trapped radicals. This finding has led Jackson to work out a comprehensive treatment of stability in trapped radical systems and of the ways in which unstable systems disappear.

This work consists of three major parts: the first part uses qualitative arguments to obtain a simple expression for a critical concentration, n_c, of trapped radicals, which, if exceeded, gives unstable systems that decay explosively; the second part consists of a detailed analysis of discrete sequences of radical reactions, with an analysis of the circumstances under which steady states can exist; and the third part involves a study of the partial differential equations for the average values of concentrations. Remarkably, all three treatments give the same criterion for stability.

In addition to the techniques already mentioned—electron spin resonance and optical spectroscopy—the Bureau has employed mass spectrometry in studying free radicals. This method was used to study gaseous recombination kinetics, and to investigate the reactions of atoms in the gas phase. The N.B.S. also made a mass spectrometric determination of the N-atom concentration in the afterglow region of nitrogen excited by the electric discharge method. This number, which is between 1 and 2 per cent, provides an upper limit to the concentration of atoms in the condensed nitrogen.

Another group has used calorimeters to measure the energy liberated by various discharged gases condensed at 4 deg. K. Although results indicate that as much as several per cent of trapped energetic species are present in the solids produced in this fashion, this estimate is thought to be too high. Other measurements on gases condensed at 4 deg. K. included determinations of the index of refraction; the thermal conductivity; and the dielectric constant. All the results obtained were consistent with the finding that the radical concentrations generally are very low.

Investigation of Nuclear Reactor Accident in Idaho

As reported in detail in our issue of August 11, a serious accident took place at the SL-1 (Stationary Low Power No. 1) reactor at the National Reactor Testing Station of the U.S. Atomic Energy Commission near Idaho Falls, Idaho, on January 3. Before the accident, there appears to have been a continuing deterioration of the burnable poison strips within the core and a worsening of the scram performance of the control rod system. The evidence strongly indicates a nuclear accident of 50 megawatt-seconds, or more, which could credibly have been induced by rapid and extensive motion of the central control rod. The U.S. Atomic Energy Commission has now issued a report presenting the findings by a Board of Investigation examining the accident. In summary, the Board could not determine, with any certainty, what initiated the SL-1 explosion, and it is possible that one may never know. It is also possible, although it seems unlikely, that there will be discovered evidence of a cause not yet considered.

Although it cannot assign the cause or the responsibility for the explosion to any known or unknown act or condition preceding the incident, it is the judgment of the Board that, before the incident occurred, the condition of the reactor core and the reactor control system had deteriorated to such an extent that a prudent operator would not have allowed operation of the reactor to continue without a thorough analysis and review, and subsequent appropriate corrective action, with respect to the possible consequences or hazards resulting from the known deficiencies. The Board believes that such review and action should have resulted in modifications to design, administration and operation sufficient to ensure that there was no potential hazard greater than contemplated in the original hazards report and review, before reactor operation was resumed.

Cause of the Incident

The Board does not rule out the possibility of a non-nuclear event which subsequently caused a nuclear excursion although no evidence to support such a hypothesis has been discovered. Postulation that a nuclear excursion initiated the explosion appears more credible, and it is not inconsistent with the available evidence. The postulation of any other mechanism, including hydrogen explosion, sabotage, or anything else, is not supported by any known evidence, and would appear to have been an unlikely coincidence with the operation in progress, in any event.

In relating the condition of the reactor to the cause of the incident, a major consideration is that a nuclear excursion of the magnitude indicated could not have occurred without a change in reactivity of about 1 or 2 per cent, at a rate of 2 to 4 per cent per second after having achieved delayed criticality. Even if the shut-down margin of reactivity had been zero, at the time the incident occurred, it appears that such a change of reactivity could have occurred only as the result of some abrupt structural failure in the reactor, or by an unusual movement of the central control rod. It seems extremely improbable that the required motion of the central control rod (a distance greater than approximately 20in, and at a rate close to the maximum humanly possible, under the circumstances) could have occurred accidentally, unless the rod had been stuck in the shroud and became free while one or more operators were exerting a large upward force on it. While there is no direct evidence that this occurred, the necessary conditions and actions appear, at the present time, to be less implausible than those required for any other hypothesis that has been suggested.

To a large extent the plausibility of the suggested hypothesis depends upon the extent to which there is evidence of sticking of control rods, particularly the central rod, within the shrouds. The Board notes that there were a large number of occasions on which control blades did not move freely either in or out. It heard testimony that the central rod never gave trouble (although there is at least one recorded case, shortly before the incident, when the central rod did not fall freely when called upon to scram). It also heard testimony predominantly to the effect that sticking of control rods was due to malfunction of the seals. A chief operator, with a mechanics specialty, testified that he believed that clearances in the shroud had decreased—causing sticking of the blades in the shrouds. His observations were backed up primarily by the experience he had with the dummy aluminium control rod that was inserted successfully in shroud No. 4 only after several inches had been cut off the bottom of the blade.

Whether or not the incident was initiated by an operator trying to withdraw the central rod, while stuck in the shroud, the hypothesis is useful in discussing the relationships among the various factors which could have, but may not have, contributed to the accident.

(*a*) *Reactivity gain from loss of boron.*—As indicated above, a large increase in reactivity above delayed criticality, in a short time, would have been required to produce the indicated nuclear incident. If there had been a larger shut-down margin of reactivity (less mechanical loss of boron), the total distance through which the central control rod would have had to be moved would be correspondingly greater. It is conceivable that the actual rod displacement would have been inadequate in magnitude or rate to produce the excursion, under these conditions.

(*b*) *Sticking of control rods.*—The emphasis in the testimony of difficulty with rod sticking only because of seal difficulties would seem to argue that rod sticking was unrelated to the hypothesis under discussion. It is not unlikely, however, that if the rods were beginning to stick in the shrouds immediately before the shut-down on December 23, 1960, the fact that sticking because of seal difficulties was an old and

THE AMERICAN SCENE *(Continued)*

familiar problem might have been responsible for failure to recognise this later development or to bring it to the attention of higher supervision.

(*c*) *Bowing of boron strips.*—It was well known that the boron strips bowed excessively between tack welds along the outside surfaces of the fuel elements. It was also well known that it was extremely difficult to remove, manually, the central fuel elements. It appears not unlikely that the bowing of the strips caused lateral pressure to be exerted on the fuel elements, and consequently especially where full and half strips were both present, there may have been lateral pressure on the shrouds, which decreased the clearance between the control rod and the inner walls of the shroud.

(*d*) *Design and procedure.*—The hypothesised incident could not have occurred if the amount of withdrawal or the rate of withdrawal of the central control rod had been positively limited by mechanical restraint or by operational procedure.

(*e*) *Administrative controls and technical review independent of the operational organisation.*—The following observations are made, again in relation to the hypothesised incident, as factors which could have contributed to the incident :

(1) Routine technical audit, by persons independent of the operating organisation, of routine operations might have led to a more conservative course of action, with detailed knowledge of the nature, extent and possible implications of the several known deficiencies.

(2) A specific procedure for the actual operation of assembly and dismantling of the control rod drives, containing clear warning and explanation of the possible hazard associated with lifting the rod, rather than only the mechanical steps contained in the training procedure, might have reduced the magnitude or rate of displacement of the central rod during re-assembly sufficiently to prevent the occurrence of the incident.

(3) If manipulation of the control rods, during assembly and dismantling, with the reactor shut down, had not been considered a routine job, even though it involved a substantial movement of the control blades with respect to the core, added supervision might have been present and, conceivably, could have influenced the course of events in such a way as to prevent the incident.

(4) If nuclear instrumentation were left on at all times, and if audible response was present in the reactor room during the rod re-assembly, it is conceivable that indications of increasing reactivity and power level might have been recognised in time to prevent the incident, by limitation of the rate or magnitude of the displacement of the central rod.

(5) Had an operator been present in the control room, and observing the nuclear instrumentation, it is conceivable that indications of reactivity or power level increase during manipulation of the control rods during assembly and dismantling would have been such that he could have advised those in the reactor room of abnormal response, thereby preventing inappropriate displacement of the central control rod.

(6) The formal recommendation of a report on the loss of boron from the reactor core, after intensive review of the problem, was to terminate a previously established inspection routine of the fuel elements and to continue to operate the reactor. It is conceivable that continued inspection of the fuel elements could have led to additional knowledge which would have affected the decision to continue to operate, and if the report had recommended no further operation, the accident would have been prevented.

(7) The training and ability of the operating organisation appears not to have been entirely adequate, since sub-standard conditions were allowed to develop in the reactor and its components, and yet reactor operation was allowed to continue. The complexity of the chain-of-command for the SL–1 may explain, in part, the lack of effectiveness of the existing organisation in communicating with higher levels of supervision regarding these sub-standard conditions. For example, the role of the military cadre was limited, in operation of the plant, in that the cadre, while adequately trained to perform the routine shift duties involved in operating the reactor, was not by itself trained in reactor physics and nuclear safety to the high level of experience and ability normally associated with a reactor plant operating force. It is conceivable that since the high level supervision was supplied by a different part of the operating organisation (the contractor's personnel) that circumstances developed where both parts together were less effective than a single organisation would have been, and that, as a result, insufficient knowledge of one kind or another was transmitted to appropriate personnel.

Responsibility for the Incident

Knowledge of all of the factors listed above existed within the contractor's organisation and within the operating arm of the A.E.C. If the explosion occurred as a result of the hypothesised incident, responsibility cannot be limited to any one person or group of persons. The immediate responsibility for the SL–1 incident, still in the light of the foregoing discussion, was that of the contractor, in that the contractor was on-site and had immediate responsibility for all reactor operations. The Board specifically absolves the military cadre, as such, from any responsibility. Individuals of the cadre had responsibility, within the limited role played by the cadre, insofar as they acted functionally as a part of the contractor's organisation. There is no evidence, however, to show whether actions by individuals of the cadre were or were not related to the cause of the incident.

Responsibility for the performance of the contractor is that of the contracting officer and his organisation who administer the contract, i.e., the A.E.C. Idaho Operations Office Manager and his staff. To the extent that the performance of the contractor was a factor contributing to the incident, the Operations Office Manager shares responsibility for the incident. Responsibility for appraisal of the performance of the Idaho Operations Office, including functions assigned relating to reactor safety, is that of the Division of Reactor Development. To the extent that the performance of the Operations Office may have been a factor contributing to the incident, the Director, Division of Reactor Development shares responsibility for the incident. The Operations Office, in the latter half of 1960, did turn down a proposal to raise the operating power level from 3MW(t) to 8·5MW(t) on the basis that the increased power level would present an unacceptable hazard, in terms of radiation levels during routine operation, but did accept a proposal to operate at power levels up to 4·7MW(t), in that such operation did not constitute a significant change.

There appears to have been some lack of clear definition of assignments, within the A.E.C., of responsibility for ensuring continuing reactor safety appraisals and inspections, for ensuring appropriate promulgation of written standards and policies, for providing adequate technical capabilities and for determining the requirements, including the most simple and direct organisational lines, for both routine and non-routine communications. It is conceivable that clearer definition of these aspects of staff reponsibilities might also have prevented the SL–1 incident.

Gas Centrifuge Research Programme

The U.S. Atomic Energy Commission has selected the Garrett Corporation, AiResearch Manufacturing Division, of Los Angeles, California, to conduct a research programme aimed at the development of an advanced gas centrifuge for the separation of uranium isotopes. The selection of a contractor for the advanced gas centrifuge is part of the Commission's over-all research and development programme to further the technology on uranium separation by this method. Uranium-235, the product of separation plants, is used both for national defence and in peaceful applications for fuelling nuclear reactors.

Currently, the Commission's work in the gas centrifuge programme includes contracts with the University of Virginia for continuing basic research, Yale University for theoretical studies, and the Union Carbide Nuclear Company at Oak Ridge, Tennessee, for carrying out centrifuge experimental work. The gas centrifuge is one of several methods that can be used for separating uranium isotopes and was one of the methods investigated during World War II. The United States ultimately employed the gaseous diffusion method as the most economical process available and has large gaseous diffusion plants at Oak Ridge, Tennessee ; Paducah, Kentucky ; and near Portsmouth, Ohio. However, the Commission remained aware of possible advantages offered by the gas centrifuge method and resumed research on this method in 1953, subsequently expanding this work gradually as technology advanced. Much of this work was conducted at the University of Virginia.

The centrifuge separation programme is conducted on a classified basis because of its potential significance to the production of weapons materials. Industry believes that there is substantial commercial potential in the use of the gas centrifuge to provide fuels for nuclear reactors. Through the A.E.C. access permit programme, industry may, after appropriate access authorisations and security approval, do classified work and obtain access to restricted data in this area.

Award of 1962 John Fritz Medal

The Board of Award has announced that Crawford H. Greenewalt, president of E. I. du Pont de Nemours and Co., will be the 1962 recipient of the John Fritz Medal, the highest honour of the American engineering profession. Established in 1902, as a memorial to the great engineer and steelmaker whose name it bears, the medal has been presented to some of the world's most distinguished engineers and scientists, including Westinghouse, Alexander Graham Bell, Edison, General Goethals, Orville Wright, Marconi, Sperry, Hoover, Pupin, and Ketterin. Mr. Greenewalt was cited "for outstanding contributions through leadership in research, in the translation of research achievements by way of sound engineering into useful products," and through his "able championship of the American free enterprise system, both in the spoken and written word."

Presented not more than once in any year for scientific or industrial achievement in any field of pure or applied science, the John Fritz Medal is sponsored jointly by the American Society of Civil Engineers, the American Institute of Mining, Metallurgical and Petroleum Engineers, the American Society of Mechanical Engineers, the American Institute of Electrical Engineers, and the American Institute of Chemical Engineers. Mr. Greenewalt has been president, chairman of the Executive Committee, and a member of the Finance Committee of E. I. du Pont de Nemours and Co. since January, 1948, the peak in a career begun in 1922 when he joined the Philadelphia Works of the company as a chemist. Before assuming the presidency, Mr. Greenewalt had been stationed in four manufacturing and two auxiliary departments, and had been a vice-president and a director of the company. During World War II he played an important role in the company's part in the American atomic energy programme that culminated in the design, construction, and successful operation of the Hanford plutonium plant. It was his responsibility to maintain liaison between Du Pont and the University of Chicago, translating the University's nuclear research developments into practical application at the Hanford Works.

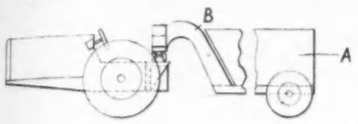
BRITISH PATENT SPECIFICATIONS

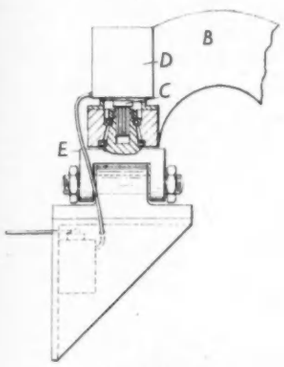
The dates printed are those of application and publication on completion. Copies of specifications may be obtained at the Patent Office Sales Branch, Southampton Buildings, Chancery Lane, W.C.2, 3s. 6d. each

VEHICLES

878,485. July 19, 1960.—POWER STEERING, More Wear Industries (Rhodesia) (Private) Ltd., Stand 6368, Hood Road, Southerton, Salisbury, Southern Rhodesia.

This invention relates to power steering mechanism for articulated four wheeled vehicles and is particularly adapted for use with a two wheeled tractor operating as a front wheel drive and attached to a two wheeled trailing vehicle to make a four wheeled articulated vehicle. The drawings show the outline of a four-wheeled tractor from which the front wheels have been removed. The two-wheeled trailer *A* is supported at the front by a gooseneck beam *B* resting on a coupling mechanism on the rear of the tractor. This arrangement allows the forward part of the tractor to be carried on its chassis acting as a cantilever





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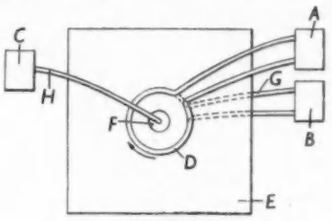
fulcrumed about the axle. Steering is by movement of the articulated members of the vehicle about the pin *C*. The pin is rotated by a hydraulic motor *D*, fed from the hydraulic system of the tractor. In travelling the axle of the trailer may be tilted relative to the axle of the tractor. To allow for such movement the coupling *E* is mounted on a hinge secured to the back of the tractor on a heavy bracket, the hinge pin having its axis in line with the longitudinal axis of the tractor.—*October* 1, 1961.

ELECTRONICS

877,626. September 30, 1958.—SUPERCONDUCTOR ELEMENTS, International Business Machines Corporation, 590 Madison Avenue, New York 22, New York, United States of America.

The present invention relates to superconductor elements and to modulating and gating circuitry employing the magnetic shielding property of a superconductor material. A plan view of the structure of a modulating circuit constructed in accordance with the principles of the invention is shown in the drawing. The purpose of the circuit is to modulate the transmission of signals, applied by a signal source *A* to the circuit, and deliver the signals in modulated form to a further utilisation circuit schematically represented by the box *B*. The modulating or control signals for the circuit are supplied by a signal source *C*. The input signals supplied by source *A* are applied to an input coil *D* which is mounted on the upper side of a sheet of superconductor material *E*. Sheet *E* may be tantalum and be maintained at a temperature of 4.2 deg. K which is the boiling temperature of liquid helium at atmospheric pressure. The tantalum, when maintained at this temperature, is normally in a superconductive state but can be driven to a normal state by the application of a magnetic field having an intensity of about 85 oersteds. The modulated outputs for the circuit are developed on a second coil *G* which has the same configuration as coil *D* and is mounted immediately beneath that coil on the opposite side of sheet *E*. The sheet is provided with an opening *F* which is positioned through the sheet in a direction perpendicular to the plane in which the sheet extends. Coils *D* and *G* mounted on opposite sides of sheet are arranged in planes parallel to the plane of sheet *E*. Control or modulating signals are applied to the circuit by a drive conductor *H* which is coupled to signal source *C* and is arranged to extend through the opening *F* in sheet *E*. The input signals applied to coil *D* are of insufficient magnitude to drive the superconductor material of sheet *E* from a superconductive to a normal state. When, with no signal applied by source *C* to drive conductor *H*, an input signal is supplied by source *A* to input coil *D*, the superconductor sheet prevents any appreciable signal from being induced in the output coil *G*. This is due to the fact that, though some amount of flux may then couple the coils *D* and *G* through opening *F*, any appreciable flux linkage between the coils would have to encompass a portion of the superconductive material. When a signal is applied by source *C* to conductor *H*, a magnetic field extending in the plane of sheet *E* is produced, which field, when the signal applied is of sufficient magnitude, causes the portions of the superconductor material immediately adjacent opening *F* to be driven to a normal state. The intensity of the magnetic field produced by energizing drive conductor *H* is strongest at points immediately adjacent this conductor and



No. 877,626

decreases as the field extends outwardly in circular fashion from the conductor. Therefore, increasing magnitudes of signal applied to conductor *H* are effective to drive increasingly larger circular portions of the superconductor material around opening *F* into a normal state. In order to allow magnetic coupling between coils *D* and *G*, it is necessary to provide a flux path surrounding them which does not include within it any superconductive material. As the magnitude of the signals applied by conductor *H* is increased, thereby driving increasing portions of sheet *E* into a normal state, the width of the circular return flux path is increased thereby improving the flux linkage between coils and increasing the magnitude of the output signals induced in coil *G*. Thus the degree of magnetic coupling between coils *D* and *G* is dependent on the magnitude of the signals applied to conductor *H*, these latter signals modulating the transmission of signals from coil *D* to coil *G*. This may be accomplished, for example, by continuously applying an input alternating current signal to coil *D* and applying a varying signal to conductor *H*. No appreciable output signal will be induced on coil *G* except when the signal applied to conductor *H* is of sufficient magnitude to drive a circular portion of the sheet *E* which extends outside the coils *D* and *G* from a superconductive to a normal state, and the magnitude of the output pulse is increased as the magnitude of the input signal above this minimum signal is increased.—*September* 20, 1961.

MINING MACHINERY

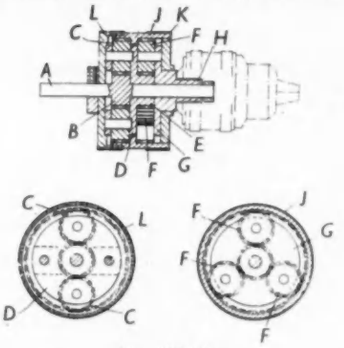
879,923. January 29, 1958.—LONGWALL MINING APPARATUS FOR CONTROLLING THE ROOF, Gewerkschaft Eisenhütte, Westphalia, Wethmar, near Lünen, Westphalia, Germany.

This invention is concerned with apparatus for controlling the roof of a face in longwall mining. In the caving method, it has been found that the roof layers directly over the seam generally break down only at a relatively considerable distance from the coal face. These layers could be considered, in a sense, as slabs which are clamped at one end between the seam and the roof and which, depending on their thickness and nature, are quite capable of accepting the roof loads for a certain time if the cantilevered length is not too great. This invention consists of longwall mining using a coal plough on a conveyor in front of the coal face, and means for providing at the rear of the apparatus a line of weakening in the roof which extends substantially parallel to the coal face. In employing such apparatus, it is possible to dispense with any roof support structure, if appropriate. In order to provide additional safety, however, the face region can also be protected by a wall from the goaf, or the roof may be supported to some extent near the waste edge. The roof may be weakened by cutting a slot or by drilling a series of holes and it is possible to support the roof at the desired breaking-off line by a knife-edge roof bar. With increasing roof pressure, the knife edge penetrates and brings about the desired detachment of the free end section of the roof projecting beyond the roof bar. Instead of individual roof bars with knife edges, it would also be possible to provide props with correspondingly constructed heads, spaced at intervals. The apparatus can conveniently be guided directly or indirectly on a conveyor situated in front of the coal face, so that it is shifted forwards with the conveyor. Four designs of apparatus for carrying out the invention are illustrated by way of example in the specification.—*October* 11, 1961.

MACHINE TOOLS

879,040. January 11, 1960.—EPICYCLIC GEARING, John M. Perkins and Smith Ltd., London Road Works, London Road, Braunston, near Rugby, and Joseph Trevor Goodwin, 253, Bilton Road, Rugby.

The object of this invention is to provide epicyclic reduction gearing for use with machine tools, and whereby torque from a shaft driven at a relatively high speed can be utilised for cutting screw-threads, or operations where accurate control and reverse rotation of a tool may be required. There is described an attachment for use with portable electric drilling machines. Referring to the drawings the attachment



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input shaft *A* has mounted on it a sun pinion *B* which is in mesh with a pair of planetary pinions *C* which are mounted on a planetary pinion carrier *D*. Formed on the carrier is a second sun pinion *E*, the carrier and pinion being freely rotatable on the shaft *A*. The sun pinion *E* is in mesh with three planetary pinions *F* mounted upon a second carrier *G* rotatable on the shaft. The carrier *G* has on it an output shaft in the form of an externally screw-threaded sleeve *H* with a tool chuck. Surrounding the carriers *D* and *G* is a sleeve *J* on the internal periphery of which are two rows of teeth which mesh with the pinions *C* and *F*. The rows of teeth are separated by an annular rib. At one end *K* on the periphery of the sleeve *J* is a knurled part to facilitate its being gripped within the hand. Surrounding the other end of the sleeve is a second knurled ring *L* formed as part of a disc and secured to the carrier *D* by a pair of screws. This disc is rotatable with the carrier, but is prevented from moving axially on the shaft by a collar. Conveniently, the sun pinions and the planetary pinions all have the same number of teeth. Thus in use when the sleeve *J* is held stationary to serve as a reaction member with the input shaft rotating, the output shaft will rotate in the same direction as the input shaft through a 16 : 1 reduction gear. However, when the ring *L* is held stationary, the output shaft will rotate in the opposite direction to the input shaft through a 4 : 1 reduction gear. When the sleeve *J* and ring *L* are released they will rotate in opposite directions at different speeds without imparting movement to the output shaft provided sufficient resistance to rotation is imparted to the shaft. By this arrangement the gearing provides convenient means for cutting of threads since only a relatively light grip is required upon the ring *K* in order to cause the sleeve *J* to act as the reaction member and transmit required torque to a tool in the chuck on the output shaft, thereby providing a sensitive control of the tool. When it is required to withdraw the tool from the work, by gripping the ring *L* rotation of the tool at a faster speed in the opposite direction can quickly and readily be effected.—*October* 4, 1961.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

Mon., Nov. 13.—BOURNEMOUTH AND DISTRICT BRANCH : South Western Hotel, Holdenhurst Road, Bournemouth, "Electrics in Aircraft," R. Renshawe, 8 p.m. ★ CENTRAL LONDON BRANCH : Police Driving School, Hendon, "Methods and Practice," 7.15 p.m. ★ NORTH WEST LONDON BRANCH : Century Hotel, Wembley, "Relays and Control Circuits," W. L. Stern, 8.15 p.m.

Tues., Nov. 14.—ALDERSHOT AND DISTRICT BRANCH : Queens Hotel, Farnborough, Hants., "Instrumentation," 8 p.m. ★ BRISTOL AND WEST OF ENGLAND BRANCH, GRADUATES' SECTION : Grand Hotel, Bristol, "Special Pyrotenax Cables," R. W. Sutherland, 8 p.m. ★ CHESTER AND DISTRICT BRANCH : Blossoms Hotel, Chester, "Some Aspects of Electricity Distribution in Rural Areas," H. V. Hayes, 7.45 p.m. ★ EAST KENT BRANCH : Clarendon Hotel, Broadstairs, "Some Aspects of Consulting Engineering," A. Ellis, 8 p.m. ★ GLASGOW BRANCH : Kenilworth Hotel, 5, Queen Street, Glasgow, C.2, "Electrical Maintenance," 8 p.m. ★ LEICESTER BRANCH : Westcotes Constitutional Club, 124, Wilberforce Road, Leicester, "Electro-Magnetic Techniques in Flow Detection," L. H. Mansell, 7.30 p.m. ★ NATIONAL EVENT : Magnet House, Kingsway, London, W.C.2, "The Contribution of Nuclear Reactors to Engineering Progress," K. J. Wootton, 6.15 p.m. ★ OXFORD AND DISTRICTS BRANCH : Board Room, Employment Exchange, St. Aldates, Oxford, "The Uses and Installation of Mineral Insulated Covered Cables," 7.30 p.m. ★ YORK BRANCH : Royal Station Hotel, York, "Pumps and Pumping," J. H. Trougher, 7.30 p.m.

Wed., Nov. 15.—EAST ANGLIA (THETFORD) CENTRE : Red Lion Hotel, Thetford, Norfolk, "Electric Motor Control Gear," R. F. Mathieson, 7.30 p.m. ★ PORTSMOUTH AND DISTRICT BRANCH : R.A.F.A. Club, Cosham, Portsmouth, "Pyrometry: The Technique of Temperature Measurement," 7.30 p.m. ★ WOLVERHAMPTON AND DISTRICT BRANCH : Chamber of Commerce, District Bank Chambers, Lichfield Street, Wolverhampton, Staffs., "Transportation of Heavy Loads," S. Bowskill, 7.45 p.m.

Sat., Nov. 18.—NORTH LONDON BRANCH : Visit to Guinness Brewery, Park Royal, 2.30 p.m.

BRITISH INSTITUTION OF RADIO ENGINEERS

To-day, Nov. 10.—SOUTHERN SECTION : College of Technology, Portsmouth, "Recent Advances in Low Noise Microwave Valves," D. G. Kiely, 7 p.m.

Wed., Nov. 15.—RADAR GROUP : London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1, "Infra-red Applications in Navigation," C. M. Cade, 6 p.m. ★ SOUTH WESTERN SECTION : College of Science Technology, Ashley Down, Bristol, 7, "Introduction to Analogue Computers," P. G. Davies, 7 p.m. ★ MERSEYSIDE SECTION : Walker Art Gallery, Liverpool, "The Guidance of Bats and Men by Echo-Location," L. Kay, 7.30 p.m.

CHEMICAL SOCIETY

Thurs., Nov. 16.—CENTENARY LECTURE : Burlington House, London, W.1, "Some Reactions of Free Radicals," G. B. Kistiakowsky, 7.30 p.m.

COMBUSTION ENGINEERING ASSOCIATION

Thurs., Nov. 16.—WESTERN REGION : Seabank Hotel, Porthcawl, Glam., "Shortcomings of Combustion Equipment," M. W. Thring, 10.30 a.m.

DIESEL ENGINEERS AND USERS ASSOCIATION

Thurs., Nov. 16.—Institute of Marine Engineers, 76, Mark Lane, London, E.C.3, "Application of C.I. Engines to Cranes and Excavators," G. A. Scott and J. K. Bellamy, 2.30 p.m.

ILLUMINATING ENGINEERING SOCIETY

Mon., Nov. 13.—SHEFFIELD CENTRE : Grand Hotel, Sheffield, "The New I.E.S. Code," H. E. Bellchambers, 6.30 p.m. ★ STOKE-ON-TRENT GROUP : North Stafford Hotel, Stoke-on-Trent, "Lighting Journey down the Rhine," E. J. Smith, 6 p.m.

Tues., Nov. 14.—LONDON CENTRE : Federation of British Industries, Tothill Street, London, S.W.1, "Changes in the Dimensions of Incandescent Lamps," A. G. Penny ; "A Standard Heat Test Lamp for the Temperature Testing of Lighting Fittings," J. N. Bowtell and J. R. Coaton, and "Temperatures in Lighting Equipment with Incandescent Lamp," J. Keen and H. F. Stephenson, 5.30 p.m. ★ GLASGOW CENTRE : Institution of Engineers and Shipbuilders in Scotland, 39, Elmbank Crescent, Glasgow, C.2, "The Mining Electrical Engineer Looks at Lighting," J. Rae, 6 p.m.

INSTITUTE OF MARINE ENGINEERS

Mon., Nov. 13.—WEST OF ENGLAND SECTION : Smith's Assembly Rooms, Westgate Buildings, Bath, "The Saint Lawrence Seaway," J. C. G. Hill, 7.30 p.m.

Tues., Nov. 14.—Memorial Building, 76, Mark Lane, London, E.C.3, "Trials and Operation of the Gas Turbine Ship 'Auris'," R. M. Duggan and A. T. O. Howell, 5.30 p.m.

Thurs., Nov. 16.—KINGSTON UPON HULL AND HUMBER AREA SECTION : Royal Station Hotel, Kingston upon Hull, "Marine Salvage," A. Lynas, 7.30 p.m. ,

Fri., Nov. 17.—SCOTTISH SECTION : Robert Gordon's Technical College, Aberdeen, Joint meeting with the Aberdeen Mechanical Society, "Elementary Nuclear Engineering," H. F. Close, 7.30 p.m.

Mon., Nov. 20.—SOUTH WALES SECTION : South Wales Institute of Engineers, Park Place, Cardiff, "Marine Machinery Breakdowns," J. H. Milton, 6 p.m.

INSTITUTE OF METALS

Mon., Nov. 13.—SCOTTISH LOCAL SECTION : Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, C.2, "The Effects of Irradiation on Materials," H. M. Finniston, 6.30 p.m.

Tues., Nov. 14.—WEST OF ENGLAND METALLURGICAL SOCIETY : College of Science and Technology, Ashley Down, Bristol, 7, Discussion on "Teaching Metallurgy to Metallurgists and Engineers," opened by J. G. Ball and L. W. Derry, 7 p.m.

Mon., Nov. 20.—NORTH EAST METALLURGICAL SOCIETY : Cleveland Scientific and Technical Institution, Corporation Road, Middlesbrough, "Recent Advances in the Foundry," A. T. Andrew, 7.30 p.m.

INSTITUTE OF NAVIGATION

Fri., Nov. 17.—Royal Institution of Naval Architects, 10, Upper Belgrave Street, London, S.W.1, "The Navigation and Guidance of Supersonic Aircraft," William L. Polhemus, 5.30 p.m.

INSTITUTE OF PETROLEUM

Wed., Nov. 15.—61, New Cavendish Street, London, W.1, Joint meeting with A.S.L.I.B., "The Technologist and his Information Facilities," R. Snel, 5.30 p.m.

INSTITUTE OF PHYSICS AND THE PHYSICAL SOCIETY

To-day, Nov. 10.—SOUTH WALES BRANCH : College of Technology, Newport, "Colour Television : Principles and Practice," K. Hacking, 6 p.m. ★ NON-DESTRUCTIVE TESTING GROUP : 47, Belgrave Square, London, S.W.1, Discussion on "The Role Played by Dislocation in Determining Mechanical Properties of Materials," 2.15 p.m.

Mon., Nov. 13.—MANCHESTER AND DISTRICT BRANCH : The University, Manchester, "The Role of the Physicist in Process Control," L. J. R. Postle, 6.45 p.m.

Tues., Nov. 14.—ELECTRONICS GROUP : 47, Belgrave Square, London, S.W.1, "Electron Beam Parametric Amplifiers," 5.30 p.m.

INSTITUTION OF CHEMICAL ENGINEERS

Mon., Nov. 13.—MIDLANDS BRANCH : Midland Hotel, Stephenson Place, Birmingham, 1, "Some Performance Data on a New Tray Column," Max Leva, 6.30 p.m.

Tues., Nov. 14.—NORTH WESTERN BRANCH : Chemical Engineering Theatre, Manchester College of Science and Technology, Jackson Street, Manchester, Programme of Papers on "Chemical Reaction Engineering," 3 p.m.

Wed., Nov. 15.—NORTH WESTERN BRANCH : Houldsworth School of Applied Science, The University, Leeds, 2, "The Thermodynamics of Separation Processes," G. G. Haselden, 6.30 p.m.

INSTITUTION OF CIVIL ENGINEERS

Tues., Nov. 14.—Great George Street, Westminster, London, S.W.1, "Structural Problems in the Use of Cold-Formed Steel Sections," A. H. Chilver, 5.30 p.m.

Thurs., Nov. 16.—TRAFFIC ENGINEERING GROUP : Great George Street, Westminster, London, S.W.1, Discussion on "Overhead Pedestrian Ways," introduced by J. W. Dark, 5.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

To-day, Nov. 10.—NORTH SCOTLAND SUB-CENTRE : Robert Gordon's Technical College, Aberdeen, "Thermistors—their Theory, Manufacture and Application," R. W. A. Scarr and R. A. Setterington, 6 p.m.

Sat., Nov. 11.—LONDON GRADUATE AND STUDENT SECTION : Visit to G.P.O. Brent Radio Terminal, 10 a.m.

Mon., Nov. 13.—LONDON GRADUATE AND STUDENT SECTION : Savoy Place, London, W.C.2, "The Work of the B.B.C. with particular reference to Transmitters," R. W. Leslie, 6.45 p.m. ★ MERSEY AND NORTH WALES CENTRE : Royal Institution, Liverpool, "Some Notes on the Electrical Requirements of General Cargo Docks," E. R. Radway, 6.30 p.m. ★ NORTH-EASTERN CENTRE : Neville Hall, Westgate Road, Newcastle upon Tyne, "Electronic Analogue Computer Simulation of Multi-Machine Power System Networks," J. G. Miles, and "Analysis of Overall Stability of Multi-Machine Power Systems," J. G. Miles, 6.15 p.m. ★ SCOTTISH ELECTRONICS AND MEASUREMENT GROUP : Royal College of Science and Technology, Glasgow, "Numerical Control of Machine Tools," D. F. Walker, 6 p.m. ★ SOUTH MIDLAND CENTRE : Winter Gardens, Malvern, "Lighting for Monochrome T.V. Productions," P. Catlett, and "Colour T.V. Production Problems," I. Atkins, 7.30 p.m. ★ SOUTH MIDLAND SUPPLY AND UTILISATION GROUP : College of Advanced Technology, Gosta Green Birmingham, "Electricity in the Manufacture of Hydrogen Peroxide," B. E. A. Vigers and R. O. Fletcher, 6 p.m. ★ NORTH STAFFORDSHIRE SUB-CENTRE : Duncan Hall, Stone, Staffs., "Data Transmission," R. H. Franklin and J. Rhodes, 7 p.m. ★ WESTERN CENTRE : University Engineering Laboratories, Bristol, "Technical and Economic Aspects of the Supply of Reactive Power in England and Wales," W. Casson and H. J. Sheppard, 6 p.m.

Tues., Nov. 14.—MEASUREMENT AND CONTROL SECTION : Savoy Place, London, W.C.2, "Tracking in Insulation," W. Parkman, 5.30 p.m. ★ NORTH MIDLAND CENTRE EDUCATION DISCUSSION CIRCLE : College of Technology, Calverley Street, Leeds, Discussion on "The Integration of Industrial and Academic Training," opened by J. S. Hudson, 6.30 p.m. ★ NORTH-WESTERN CENTRE : Engineers' Club, Albert Square, Manchester, 2, "Progress in Oil-Filled Cables and their Accessories," A. N. Arnam, F. J. Miranda and G. R. Bishop, and "The Influence of Ageing on the Characteristics of Oil-Filled Cable Dielectric," P. Gazzana Priaroggia, G. L. Palandri and U. A. Pelagatti, 6.15 p.m. ★ NORTHERN IRELAND CENTRE : Lecture Theatre LG25, David Keir Building, Queen's University, Stranmillis Road, Belfast 9, "The Potentialities of Artificial Earth Satellites for Radio-communication," W. J. Bray, 6.30 p.m. ★ SCOTTISH ELECTRONICS AND MEASUREMENT GROUP : Carlton Hotel, Edinburgh, "Numerical Control of Machine Tools," D. F. Walker, 7 p.m. ★ SOUTHERN ELECTRONICS AND CONTROL GROUP : The University, Southampton, "High-Speed Ferrite Core Stores," P. Cooke, 6.30 p.m.

Wed., Nov. 15.—LONDON GRADUATE AND STUDENT SECTION : Visit to G.P.O. Research Station, Dollis Hill, 2.15 p.m. ★ EAST ANGLIAN SUB-CENTRE : Electric House, Ipswich, Third Hunter Memorial Lecture, "The Application of Electronics to the Electricity Supply Industry," J. S. Forrest, 6.30 p.m. ★ SHEFFIELD SUB-CENTRE : Grand Hotel, Sheffield, "The Engineering Aspects of Plasma Physics," D. L. Smart, 6.30 p.m. ★ SOUTHERN CENTRE : C.E.G.B. Offices, High Street, Portsmouth, "A General Theory of Depreciation of Engineering Plant," D. Rudd, 6.30 p.m.

Thurs., Nov. 16.—UTILISATION SECTION : Savoy Place, London, W.C.2, "The Design and Performance of High- and Low-Voltage Terminal Boxes," K. K. Schwarz, 5.30 p.m. ★ LONDON GRADUATE AND STUDENT SECTION : Visit to Associated Newspapers, 9.30 p.m. ★ IRISH BRANCH : Physical Laboratory, Trinity College, Dublin, "Performance of E.S.B. Transmission System after 35 Years," P. J. Tierney, 6 p.m.

Fri., Nov. 17.—NORTH EASTERN GRADUATE AND STUDENT SECTION : Grey Hall, King's College, Newcastle upon Tyne, "The Transient Performance of the Synchronous Generator," M. W. Kennedy, 6.30 p.m.

Sat., Nov. 18.—LONDON GRADUATE AND STUDENT SECTION : Visit to Arthur Guinness, Son and Co. (Park Royal) Ltd., 10.30 a.m.

INSTITUTION OF ENGINEERING DESIGNERS

Mon., Nov. 13.—NORTH EAST BRANCH : New Lecture Theatre, Rutherford College of Technology, Northumberland Road, Newcastle upon Tyne, "A National Standard in Engineering Design Education," W. A. A. Witham, 7.15 p.m.

INSTITUTION OF ENGINEERS-IN-CHARGE

Tues., Nov. 14.—Magnet House, Kingsway, London, W.C.2, "The Contribution of Nuclear Reactors to Engineering Progress," K. T. Wooton, 6.30 p.m.

INSTITUTION OF HEATING AND VENTILATING ENGINEERS

Tues., Nov. 14.—BIRMINGHAM AND DISTRICT BRANCH : Engineering Centre, Stephenson Place, Birmingham, "Structural Insulation of Buildings," J. Lawrie, 6.30 p.m. ★ YORKSHIRE BRANCH : Athol Hotel, Charles Street, Sheffield, 1, "The Application of Unit Air Conditioners," E. P. Johnson, 7.30 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

To-day, Nov. 10.—LONDON GRADUATES' SECTION : 1, Birdcage Walk, Westminster, London, S.W.1, Informal Meeting, 6.30 p.m. ★ NORTH WESTERN GRADUATES' SECTION : Liverpool Engineering Society's Rooms, 9, The Temple, Dale Street, Liverpool, "Problems Associated with Small Turbines driven by High-energy Gases," M. D. C. Doyle, 7 p.m. ★ WESTERN GRADUATES' SECTION : Technical College, Brunswick Road, Gloucester, "Compressed Air and the Motor Vehicle," E. Dunn, and R. Waite, 7.30 p.m.

Mon., Nov. 13.—NORTH WESTERN A.D. CENTRE : The Crewe Arms, Crewe, Repetition of Chairman's Address, 7.15 p.m.

Tues., Nov. 14.—AUTOMOBILE DIVISION : 1, Birdcage Walk, Westminster, London, S.W.1, Nominated Lecture, "Automobile Air-Cooled Engines," J. Mackerle, 6 p.m.

Wed., Nov. 15.—NUCLEAR ENERGY GROUP : 1, Birdcage Walk, Westminster, London, S.W.1, Discussion on "The Influence of Gas-Inlet Temperature on Magnox Reactors," 6 p.m. ★ NORTH EASTERN A.D. CENTRE : Chemistry Lecture Theatre, The University, Leeds, Repetition of Chairman's Address, 7.30 p.m. ★ NORTH EASTERN GRADUATES' SECTION : Cleveland Scientific and Technical Institution, Corporation Road, Middlesbrough, "Accuracy of Measurements of Temperature, Pressure and Flow Rates," T. Dobson, and "Air Conditions for Human Wellbeing," K. O. Fish, 6.30 p.m.

Thurs., Nov. 16.—NORTH WESTERN GRADUATES' SECTION : Engineers' Club, Albert Square, Manchester, "Magnetogasdynamics," K. Ball, 7 p.m. ★ YORKSHIRE GRADUATES' SECTION : Hotel Metropole, Leeds, "Mechanical Engineering in Switzerland," D. K. Wilson, 6.45 p.m.

Fri., Nov. 17.—LONDON GRADUATES' SECTION : Technical College, Queensway, Enfield, "Recent Developments in L.T.E. Railway Rolling Stock Design," G. Styles, 7.15 p.m.

Sat., Nov. 18.—SOUTHERN GRADUATES' SECTION : Visit to Diagrit Grinding Company, Station Road, Staplehurst, near Tonbridge, Kent, 10.30 a.m. ★ SOUTHERN GRADUATES' SECTION : Visit to Deverish and Groves Ltd., Brewery, Trinity Street, Weymouth, 10 a.m.

INSTITUTION OF MINING AND METALLURGY

Thurs., Nov. 16.—Geological Society, Burlington House, Piccadilly, London, W.1., General Meeting, 5 p.m.

INSTITUTION OF PLANT ENGINEERS

Tues., Nov. 14.—MANCHESTER BRANCH : Manchester Literary and Philosophical Society's Rooms, George Street, Manchester, "High Pressure Hot Water Systems," A. E. Lock, 7.15 p.m.

Wed., Nov. 15.—EAST MIDLANDS BRANCH : Sherwood Room, County Hotel, Theatre Square, Nottingham, "Coal Utilisation," D. Hicks, 7 p.m. ★ KENT BRANCH : Railway Hotel, Dartford, "Hydraulic Control Systems," J. C. Wells, 7 p.m.

Thurs., Nov. 16.—BLACKBURN BRANCH : Castle Hotel, Blackburn, "The Free Piston Engine," W. Lowe, 7.30 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

To-day, Nov. 10.—EASTERN REGION : Davey, Paxman and Co. Ltd., Britannia Works Canteen, Colchester, Essex, "Packing," J. E. Evan-Cook, 7.30 p.m.

Mon., Nov. 13.—EAST AND WEST RIDINGS REGION : Percival Whitley College of Further Education, Francis Street, Halifax, "Design and Development of Machine Tools," C. A. Sparkes, 7.30 p.m. ★ EAST AND WEST RIDINGS REGION : Grand Hotel, Sheffield, "Human Relations in Industry," E. Fletcher, 6.30 p.m.

Tues., Nov. 14.—EAST AND WEST RIDINGS REGION : Technical College, Waterdale, Doncaster, "Synthetic Fibres used in Engineering," 7 p.m. ★ BIRMINGHAM GRADUATE SECTION : James Watt Memorial Institute, Birmingham, "Stress Forming," A. M. Redman, 7 p.m.

Wed., Nov. 15.—WESTERN GRADUATE SECTION : Small Lecture Theatre, Faculty of Engineering, Queen's Building, The University, Bristol, "Venue Open to Production Engineers," F. Pitts, 7.30 p.m. ★ MIDLANDS REGION : James Watt Memorial Institute, Birmingham, "Some Aspects of the Design of Machine Tools and Automation Equipment for the Future," F. A. Lewis, 7 p.m. ★ NORTH MIDLANDS REGION : F. Perkins Ltd., Conference Room, Peterscourt, Peterborough, "Surface Finish," R. E. Reason, 7.30 p.m.

Thurs., Nov. 16.—NORTH MIDLANDS REGION : Grand Hotel, Leicester, "The Russian Approach to Production," M. Seaman, 7.15 p.m. ★ NORTH MIDLANDS REGION, LOUGHBOROUGH COLLEGE STUDENT SECTION : Room A1, Schofield Building, College of Technology, Loughborough, Leics., "The Design of Blue Bird," D. L. Stevens, 7.30 p.m. ★ SCOTLAND REGION : Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, C.2, "Chipless Turning," E. J. Bennett, 7.30 p.m. ★ SOUTHERN REGION : Great Western Hotel, Station Road, Reading, "Cost Control for the Production Engineer," F. G. S. English, 7.30 p.m. ★ SOUTHERN REGION : Polygon Hotel, Southampton, "Production Control—Provisioning Aspects," H. Horne, 7.15 p.m.

INSTITUTION OF STRUCTURAL ENGINEERS

To-day, Nov. 10.—SOUTHERN BRANCH : The University, Southampton, Chairman's Address, J. R. Lowe, 6.30 p.m.

Mon., Nov. 13.—LANCASHIRE AND CHESHIRE BRANCH : College of Science and Technology, Manchester, "Architectural Misconceptions of Engineering," A. J. Harris, 6.30 p.m.

Wed., Nov. 15.—MIDLAND COUNTIES BRANCH, GRADUATE AND STUDENTS' SECTION : Electricity Demonstration Hall, Irongate, Derby, "Elevated Roadways," G. B. Smedley, 6.15 p.m. ★ SCOTTISH BRANCH : Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, C.2, "Who Teaches the Science of Welding?" J. Orr, 7 p.m.

INSTITUTION OF WATER ENGINEERS

Wed., Nov. 15.—SOUTH EASTERN SECTION : Institution of Civil Engineers, Great George Street, Westminster, London, S.W.1, "Overland to the U.S.S.R.," F. Needham Green, and Film, "Hold Back the Sea," 2.30 p.m.

JUNIOR INSTITUTION OF ENGINEERS

To-day, Nov. 10.—Pepys House, 14, Rochester Row, Westminster, London, S.W.1, "Food at Zero," R. M. Cooper, 7p.m.

Fri., Nov. 17.—Pepys House, 14, Rochester Row, Westminster, London, S.W.1, Chairman's Address, "Some Notes on Early Marine Diesel Engines," E. E. Burrage, 7 p.m.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS

To-day, Nov. 10.—Mining Institute, Newcastle upon Tyne, "Photoelasticity and its Application in Marine Engineering Research and Development," J. West and F. S. Lynn, 6.15 p.m.

PLASTICS INSTITUTE

Fri., Nov. 17.—MIDLANDS SECTION : James Watt Memorial Institute, Great Charles Street, Birmingham, 3, "Blow Moulding of Thermoplastics," M. C. Dixon, 6.30 p.m.

REINFORCED CONCRETE ASSOCIATION

Tues., Nov. 14.—MIDLAND COUNTIES BRANCH : Birmingham and Midland Institute, Paradise Street, Birmingham, "The Architectural Aspects of the Design, Detailing and Execution of Reinforced Concrete Shells," H. S. Scorer, 6 p.m.

ROYAL INSTITUTION OF CHARTERED SURVEYORS

Mon., Nov. 13.—12, Great George Street, London, S.W.1, Presidential Address, E. C. Strathon, 5.45 p.m.

ROYAL SOCIETY OF ARTS

Wed., Nov. 15.—John Adam Street, Adelphi, London, W.C.2, "Engineering and Architecture," Riccardo Morandi, 6 p.m.

SOCIETY OF CHEMICAL INDUSTRY

Wed., Nov. 15.—CORROSION GROUP : 14, Belgrave Square, London, S.W.1, Controversial Evening, 6 p.m.

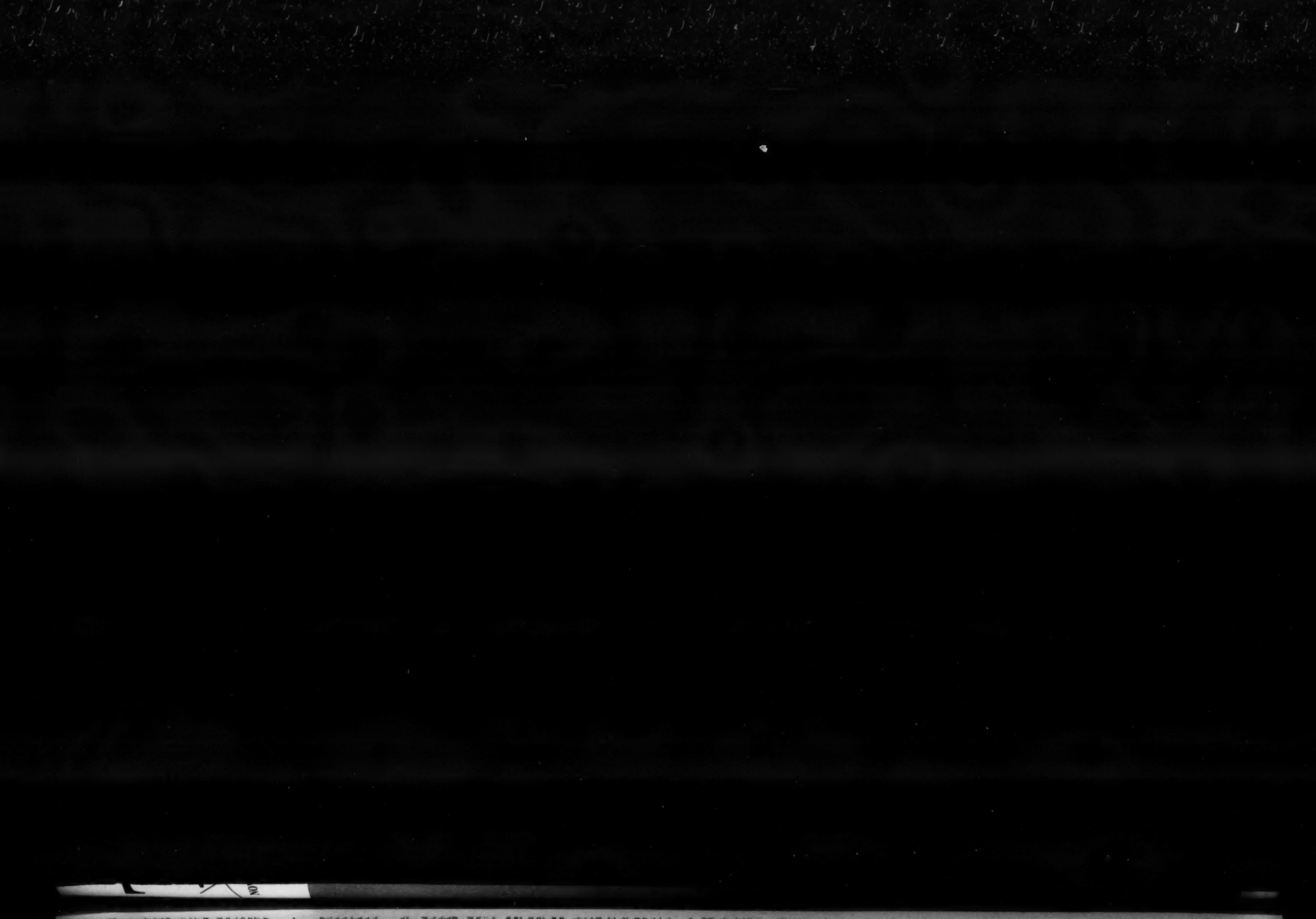
Thurs., Nov. 16.—ROAD AND BUILDING MATERIALS GROUP : 14, Belgrave Square, London, S.W.1, "Road Building in the Tropics," R. S. Millard, 6 p.m.

SOCIETY OF INSTRUMENT TECHNOLOGY

Thurs., Nov. 16.—DATA PROCESSING SECTION : Manson House, 26, Portland Place, London, W.1., "Digital Techniques for the Study of Sea Waves, Ship Motion and Similar Processes," D. E. Cartwright, M. J. Tucker, and Miss D. B. Catton, 6.30 p.m.

SOUTH WALES INSTITUTE OF ENGINEERS

Thurs., Nov. 16.—Park Place, Cardiff, "Some Problems of Shaft Inset and Pit Bottom Roadway Construction at Abernant Colliery," T. Vaughan Thomas, 6 p.m.

WEST OF SCOTLAND IRON AND STEEL INSTITUTE

Thurs., Nov. 16.—39, Elmbank Crescent, Glasgow, Junior Members' Night, Papers on "Marking, Cutting and Testing of Steel," 6.45 p.m.